

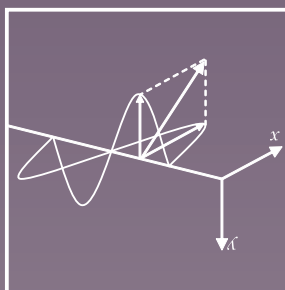
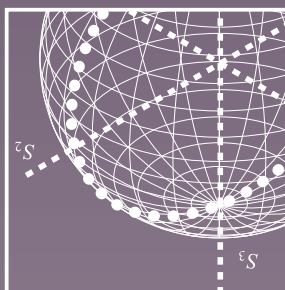
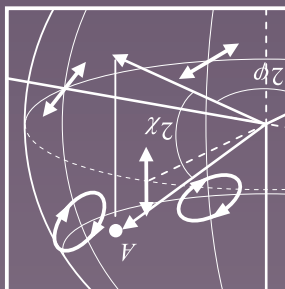
To users measuring angle of rotation  
with conventional polarimeters

# Polarimeter Guide

$$S_{OUT} = A(90^\circ) \cdot T(\theta) \cdot P(\phi) \cdot S_{IN}$$

$$S_{OUT} = \begin{bmatrix} S_{out0} \\ S_{out1} \\ S_{out2} \\ S_{out3} \end{bmatrix} = \frac{1}{2} \begin{bmatrix} 1 & \cos 2\phi & 0 & 0 \\ \cos 2\phi & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} 2 \\ 1 \\ \cos 2\phi \\ \sin 2\phi \cos 2\phi \end{bmatrix}$$



# 27 Applications

A Deep & Entertaining Discussion About Polarimeters

**Polarimeter Guide**

## The Complete Polarimeter Guide

### A Comprehensive Collection of 27 Applications

Everything from sugars and corn syrup in the sugar refining industry, the drug manufacturing and pharmaceutical industries, to beverages and food product additives—all 27 applications collected in one book!

### The Definitive Polarimeter Guide

This guidebook is the bible of selecting polarimeters. You will soon know everything you need to know about polarimeters!

A3 Sugar	A12 Alcohol
A4 High Fructose Corn Syrup	A13 Lactose
A5 Inverted Sugar	A14 Collagen
A6 Rare Sugar	A15 Feed
A7 Honey	A16 Food Additives
A8 Fragrance & Flavor	A18 Pharmaceutical & Medical
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## Sugar

### An Important Source of Energy For Our Bodies

Sugar falls under saccharides, which are among the 5 major nutrients. This means sugar is essential for a healthy life. Although "sugar" is a general term, there are in fact several different varieties that are derived from different raw and refined sugar.

By classifying raw sugar separately, we can see that it is divided into sugarcane, which is the raw source of cane sugar, and sugar beet, which is the raw source of beet sugar. The first step is to harvest the sugar content from the source, crystallize it, and convert it into raw sugar. Raw sugar is full of many impurities that give it a brown color. These impurities are removed at the factory, then the remaining substance is filtered and made into a transparent liquid. This liquid sugar is boiled down, and the resulting crystals are what we know as sugar. Furthermore, by adjusting the size of the crystals, sugar can be divided into many different types, such as granulated sugar, caster (superfine) sugar, and coarse-grain sugar. The separated, leftover, sugar-laden syrup is boiled down and the crystals are extracted; a process that is repeated several times. The crystals gradually change color over the course of this process, resulting in colorized sugar such as light brown sugar and coarse grain brown sugar. Sugar (sugarcane juice) that is squeezed straight from the source and boiled down as-is without being refined is known as muscovado.

So, what do polarimeters have to do with sugar and where do they fit in?

During the manufacturing/refining process, when impurities are removed, polarimeters are used to measure the level of purity. By measuring the purity, it can be confirmed whether or not the impurities were thoroughly removed.

Refractometers (sugar meters) can be used when taking quick measurements out in the fields for simple checks, but because the sample also contains other sugars and impurities, the result ends up reflecting the overall concentration. For this reason, polarimeters are recommended when measuring for precise, accurate purity levels of sucrose.

Until now, the majority of polarimeters were large, heavy instruments, designed and built with the assumption that they would only be used in laboratories, without ever being transported. It was simply an accepted fact of reality that polarimeter were difficult to be used in the field. Now, **the Refracto-Polarimeter RePo Series** has ushered in a new era. An easy to carry, portable, miniature instrument that combines both refractometer and polarimeter into a single unit has finally become a reality. It can be easily and freely used on-site, in the lab, and everywhere else in between.

Another point of note is that because raw sugar is darkly colored, one way of measuring it is to remove the color using lead(II) acetate or Aluminum chloride prior to measurement. However, environmental concerns and the desire to reduce time and labor costs have given rise to a growing number of requests to measure darkly colored liquids as-is with a 882nm wavelength instead of the standard 589nm wavelength.

**The SAC-i 589/882**, with its ability to measure at both wavelengths, can satisfy these demands.

ATAGO has instruments capable of fulfilling the various needs in the lab, on-site, and anywhere else. Other products in addition to the ones mentioned above are available. For details, please contact ATAGO.



## High Fructose Corn Syrup

The Sweet Taste for Hot Summer Days

"High fructose corn syrup" is often found on the ingredients listed on nutrition labels of products such as juice. It is a liquid form of sugar with glucose and fructose as its main components. Although it is commonly made from corn (cornstarch), other types of starch such as potato, sweet potato, and tapioca are also used. These raw ingredients are hydrolyzed (broken down), and an enzymatic reaction is triggered to create high fructose corn syrup. In fact, the technology for processing and producing high fructose corn syrup originated in Japan, but as the use of liquid sugar was not common practice in Japan, this refining method was adopted much sooner overseas. It has become the number one exported national patent of Japan. The way high fructose corn syrup (HFCS) is made, using enzymes and the like, isn't the only difference between HFCS and sugar; its degree of sweetness also differs. Supposing the sweetness of sugar is 100, then the sweetness of glucose is between 65 to 80, and fructose has a sweetness level between 120-170, comparatively speaking. High fructose corn syrup containing 42% fructose (HFCS 42) has a sweetness level between 70 to 90 and high fructose corn syrup containing 55% fructose (HFCS 55) has a sweetness level between 100 to 120. However, it must be noted that the perceived level of sweetness (taste-wise) varies according to temperature. For instance, fructose, in particular, only has 60% of the sweetness of sugar at high temperatures, but at 40°C it has roughly the same. At temperatures below 40°C, fructose tends to taste much sweeter than sugar.

It is difficult to solidify and powderize HFCS, so it can't be packed into bags as with sugar. As such, it is largely sold to

business such as food product manufacturers. Moreover, it's cheaper than sugar. For example, it is said that HFCS 55 costs roughly 70% as much as sugar. This is why it is used in all sorts of applications in the food industry, such as soft drinks, canned goods, and dairy products. It's also widely used in frozen desserts, as its increase in sweetness levels at low temperatures creates a more intense, refreshing sensation. Now then, what do polarimeters have to do with HFCS and where does it fit in? The different types of HFCS are sorted by their different ratios of glucose and fructose, and each kind has varying sweetness levels, with their own different purposes. Through the use of refractometers and polarimeters, it is possible to conduct tests, such as inspections at manufacturers using HFCS as a raw ingredient in their food and beverage products, not to mention HFCS manufacturing facilities. **The Refracto-Polarimeter, RePo-2** is a model specially designed for HFCS. At a size that allows it to be easily held in one hand, it can be conveniently used even at manufacturing sites.

### Percentage of Fructose Contained in HFCS

Dextroglucose-fructose syrup(HFCS 42)	less than 50%
Fructose-dextroglucose syrup(HFCS 55)	more than 50% less than 90%
High fructose syrup(HFCS 90)	more than 90%
Sugar-high fructose corn syrup blend	Contains more than 10% added sugar than the aforementioned sweeteners.

Per the Ministry of Agriculture, Forestry and Fisheries "Japan Agricultural Standard (JAS) for High Fructose Corn Syrup as well as Sugar-High Fructose Corn Syrup Blends."



## Inverted Sugar

Indispensable for Confectionery

Sucrose is broken down (inverted) into glucose and fructose. This compound of glucose and fructose is known as "inverted sugar." Inverted sugar has the syrupy, gooey, rich sweetness of fructose and possesses good moisture absorbing properties. When used in confectionery, it improves the flavor and texture (mouthfeel) of the dough, and it can extend the shelf-life of the product. When used in frozen desserts, it prevents formation of ice crystals and keeps the product from drying out, resulting in a smooth, creamy consistency. Inverted sugar is mainly used in confectionery, where these particular characteristics are utilized. There are a few ways to make inverted sugar.

### ■ From sugarcane

Using column chromatography technology, the amount of fructose can be increased to levels up to 60% by reducing the amount of glucose within the inverted sugar and increasing the fructose amount. This resulting sweetener is called "High Fructose Syrup (HFS)."

### ■ From sugar beet

Inverted sugar made from sugar beet is said to have roughly the same proportion of stable carbon isotopes (<sup>13</sup>C and <sup>12</sup>C) as orange juice. Inverted beet sugar is often used as a sweetener in orange juice for this very reason. Well then, what do polarimeters have to do with inverted sugar and how do they fit in? Inverted sugar is created by hydrolyzing a dextrorotatory substance and inverting it into a levorotatory substance. Thus, it is known as "inverted sugar." Differences in sweetness arise due to the invert

ratio of the sugar, so inverted sugar, food and beverage manufacturers must check those values. Fructose and glucose each have their own different specific rotation that correlates with sweetness, which is why it needs to be measured. The refractive index also differs, so by using these two values, it is possible to estimate the approximate amount of the invert ratio.

**The Refract-Polarimeter, RePo-3** is a model specially designed for inverted sugar. Furthermore, as a hybrid model of a refractometer and polarimeter, it is a single unit that is capable of measuring both Brix and angle of rotation.



## Rare Sugar

### A Sugar that Rarely Occurs in Nature

Are you familiar with "rare sugar?" People concerned with diet and health may have heard about it. Rare sugar is said to be a kind of sugar where consumption is not fattening but rather you lose weight; all while having nearly the same sweetness as regular sugar. After such bold claims, some people might think, "there's no way a sugar with these kind of fantastical magical effects exists!" The way rare sugar works is simple. D-psicose, a component contained in rare sugar, blocks the glucose absorbing site in the intestinal wall preventing glucose from being absorbed in the body. The unabsorbed glucose is excreted instead of being absorbed in the body.

A superabundance of nutrients can cause lifestyle diseases. The fascinating fact about rare sugar is that unlike artificial sweeteners, it is pure and genuine sugar. The effect and function of rare sugar is uncovered and understood. Two important facets in life are "enjoy eating" and "fighting obesity." Thanks to rare sugar, the two are no longer mutually incompatible. Rare sugar, as its name implies, is a kind of sugar that occurs in small quantity in nature. Its exceptional effects can help people struggling with obesity and lifestyle diseases, but even if we attempted to gather the amount needed from nature, it would not be nearly enough. Although global research into mass-production of rare sugar is underway, the most fervent research is done in Kagawa, Japan. The efforts of this research have been worthwhile; it was discovered that rare sugar can be created by adding a specific enzyme to fructose.

Well now, what do polarimeters have to do with rare sugar

and where do they fit in? Excess sugar content greatly affects the refractive index. So for sugar content of all types, measurements with refractometers are the norm. Certainly rare sugar is no exception. Aside from this, when making rare sugar, measurement of the refractive index and angle of rotation in order to check the ratio of the enzyme's reaction is an absolute must in regards to ensuring the quality of rare sugar. Observing the changes of the angle of rotation is extremely useful in measuring the denaturation of a substance caused by an enzyme reaction.



## Honey

### The Sweet Gift from Honeybees

"Honey" is a substance stored inside hives, gathered from the nectar of flowers by honeybees. It is said to be the sweetest nectar found in nature. It consists of approx. 80% sugar and 20% water, and contains a small amount of nutrients such as vitamins and minerals. In Japan, the definition of honey as designated by the "Japan Honey Fair Trade Council" is as follows.

#### ■ Composition Standards

Moisture (at 20°C)	20% and below * Note: moisture standard for domestic honey is 23% and below
Fructose + glucose (total sum)	60g/100g and above
Sucrose	5g/100g and above
Ash content (Electric conductivity)	0.8mS/cm and below
HMF	5.9mh/100g and below
Free acidity	5mL 1N acid per 100g and below (50meq acid per 1000g)
Starch dextrin	negative reaction

Nectar, the principle element of honey, is gathered by female honeybees and stored up as sucrose in an organ located at the front part of their stomach called a "honey stomach." Once the honey stomach is full of nectar, the honeybee returns to the hive, where it is processed and stored. This is what becomes honey. Nectar has a lower sugar level than honey, generally the concentration is less than 40%. After it is brought back to the hive, the moisture evaporates which increases the honey's sugar level to about 80%. It's at this point that the honeybee uses its mouthparts to stretch out the honey into a membrane-

like film. The enzyme contained in the honeybee's saliva (invertase) causes the sucrose to break down into glucose and fructose.

In the beekeeping industry, evaluating the quality of honey with sugar meters and moisture meters (both refractometers) has come into practice. Factors such as color and sheen, flavor, and fragrance are important, but sugar level is also a critical indicator of quality. Sugar level varies depending on the variety of flower, but it's roughly between 75 to 85%. Normally, the moisture content of nectar is more or less between 60 to 80% However, while it is stored inside the hive, the fanning of honeybees wings evaporates the moisture, thickening the nectar and reducing moisture to about 20%.

So then, what do polarimeters have to do with honey and where do they fit in?

By using a polarimeter, it is possible to determine if the ratio of fructose and glucose remains consistently. Since fructose and glucose have different angle of rotation, the compositional proportions will simply be displayed as differences in angle of rotation.

**The Refracto-Polarimeter, RePo-4** is a model specially designed for honey. Furthermore, as a hybrid refractometer and polarimeter model, it is capable of measuring sugar level, moisture, and angle of rotation with a single unit. At a size that fits comfortably in the palm of your hand, it can be easily and conveniently used on-site and in the field.

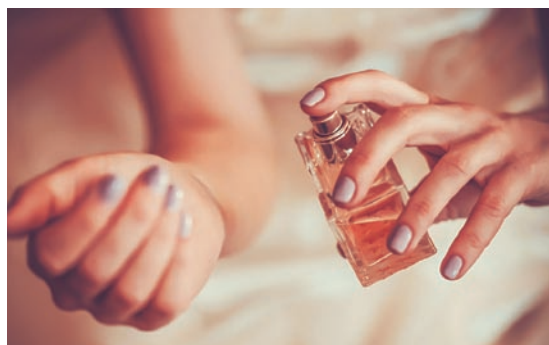


## Fragrance & Flavor

### The Sweet Essence of Danger

There are multitudes of stimuli in the world, just as our sensory organs can detect a variety of things in the same way. Humans possess the sense of sight, hearing, touch, taste, and smell, which are commonly referred to as "the five senses." Each sense corresponds with the sensory organs of our bodies, namely the eyes, ears, skin, mouth, and nose. These organs respond to the stimuli we encounter.

The experiences we receive from these five senses are often replicated and produced as commercial products. Perfumes, aromas, and fragrances are a delight to our sense of smell. In order to research how to produce these fragrances, quantitative data is essential. That being said, exactly what type of data is necessary? Well, for example, for the sense of sight, we can assign a value to "How blue is the blue-ness?" and express it in numerical terms. However, if we wish to recreate a fragrance using data, what kind of information do we need?



Fragrances are often complex compounds that are composed of numerous types of ingredients. As such, they are subject to a multitude of measurements and tests, such as physics tests including specific gravity, refractive index, angle of rotation, solubility, freezing point, melting point, boiling point, and a number of other important aspects. Many tests are done with specialized equipment, like chromatographs, for measurement, but these instruments are quite expensive and not very common. Natural fragrances are largely derived from refined oil (essential oil) and resin. Nearly all essential oils on the market have specific rotation and refractive index listed on their ingredients list. The Japanese Pharmacopoeia has set standards for specific rotation of essential oils. There is no mistaking that it's an extremely critical element. Moreover, specific rotation and refractive index measurement are tremendously useful in sorting essential oils made from 100% natural ingredients from aroma oils containing synthetic fragrances. Even if these fragrances have a similar smell, these two values will be different. Aroma oil contains an ingredient which is dangerous if it comes in direct contact with the body. Listing specific rotation and refractive index acts as a supportive means to demonstrate and validate the distinction and quality of a product.



### Peppermint oil

Mint (a species of mentha) is a plant in the order Lamiales, in the family Lamiaceae, and in the genus Mentha. The essential oil, made from the dried plants that have been steam distilled, is used in fragrances and other products. Its uses include insect repellent, deodorizer, a cure for drowsiness, a mold inhibitor, and as mint tea for relieving

loss of appetite due to summer fatigue. It is actively used in a wide variety of applications. As designated by the Japanese Pharmacopoeia, mint oil's specific rotation is  $[\alpha]_D^{20} = -17.0$  to  $-36.0^\circ$ . Polarimeters can be used to measure whether the mint oil falls within this standard value.



### Lavender oil

Lavender is a plant with many tiny flowers attached to a long stem. Its blue flowers are thought to symbolize "tranquility." Its refreshing, floral scent relaxes and improves mood as well as relieves fatigue and revitalizes our health. Furthermore, lavender can be used as external anti-septic. It can be applied to cuts, burns, sores, and pimples. When

used as an ointment, it is said to facilitate faster healing and prevent scarring. In Western countries, many common essential oils have standard specific rotation values, as designated by the European Pharmacopoeia and the United States Pharmacopoeia.



### Melaleuca alternifolia oil

Melaleuca alternifolia (commonly known as narrow-leaved paperbark, aka tea tree) is a tall tree native to New South Wales in Australia, which grows to a height of up to 7 meters. It has leaves that resemble thin, long feathers and produces yellow or purple colored flowers. About 1 kg of essential oil (tea tree oil) can be obtained from 100 kg of tea tree leaves. This essential oil has a cool, refreshing fragrance brimming with a

clean, pure essence. It possesses exceptional antimicrobial properties and deodorizing effects. Tea tree oil makes the air in a room fresh and healthful, and in regards to our mental state, it calms our mood and relieves anxiety. The components from each individual tea tree vary greatly, so there are designated quality standards for the essential oil in Australia. Specific rotation is one of the immensely crucial elements for adjusting the components, as far as standards are concerned.



### Limonene

Limonene is a component of fragrances found abundantly in citrus peels, used in scents and as a naturally derived solvent. It has a wide range of uses, and in addition to having a relaxing component, its fragrance stimulates the sympathetic nervous system and speeds up the metabolism. Furthermore, it promotes salivation, which facilitates digestion and absorption, and increases

appetite. As for aromatherapy, essential oils from citrus fruit seem to be effective for weight loss, this also is due to limonene's role in stimulating the sympathetic nervous system and breaking down fat. Limonene also dissolves packing peanuts quite well, so it is used in recycling and in kitchen cleaning detergent as well. Limonene's component standards for both refractive index and angle of rotation are often regulated by law.



## Soft Drink

### Revealing the Truth Behind "Zero Calorie"

A soft drink is the perfect beverage to quench your thirst underneath the blazing sky of a sweltering summer. It's something we modern people simply cannot live without. However, recently, soft drinks have begun to face some slight opposition. Views that their distinct "sweetness" is harmful to the body have largely arisen. The fact that they're simply "beverages" has led to careless overindulgence. The results, which are now apparent in the emerging detrimental effect of sugar. The onset of diabetes, a typical lifestyle disease, is something anyone would wish to avoid.

In light of this, particular focus has gathered on artificial sweeteners, such as aspartame and sucralose. Our sense of taste perceives these artificial sweeteners as having the same sweetness as sugar, but because they don't contain sugars that affect our bodies, its convenience gained popularity among soft drink manufacturers. Incidentally, herein lies one problem. Up to this point, refractometers have been used for measuring sugar content. The majority of refractometer scales use Brix, which is based on converted sucrose values. Managing sugar content with refractometers has become so prevalent that on occasion, "sugar meter" is a common name used to indicate refractometer. However, artificial sweeteners have sweetness levels that are hundreds to thousands times greater than sugar, so beverages contain only a tiny amount, which causes only slight changes in the refractive index, making it difficult to measure and manage sugar content with just a refractometer. What should we do to be able to measure the concentration of artificial

sweeteners used in "zero calorie" beverages? Artificial sweeteners such as aspartame and sucralose which are contained in soft drinks, are optically active. Therefore, it is possible to measure the angle of rotation and ascertain the value using a polarimeter. For quality control of "zero calorie" beverages, it is highly suggested to implement a polarimeter. (Due to the low concentration of artificial sweeteners contained in common zero calorie beverages, the value of the angle of rotation will also be significantly low. When taking measurement for quality control purposes, please use an appropriate measurable concentration.)

#### Specific Rotation of Artificial Sweeteners

Aspartame	$[\alpha]_D^{20} = +14.5$ to $+16.5^\circ$
Sucralose	$[\alpha]_D^{20} = +84.0$ to $+87.5^\circ$

Per Japan's Ministry of Health, Labour and Welfare's "Food Additives Codex."



## Tea

### For "Quali-Tea"

For most people, "catechin" would be the first thing that comes to mind upon hearing the phrase, "the main component contained in tea." Catechin is the primary component that makes up tea's astringent taste; it is a type of tannin. Tea also contains polyphenols, which are recognized in other beverages such as wine for their antioxidation effect. Green tea in particular contains an abundance of polyphenols. Due to its taste, catechin used to have somewhat of an unfavorable image, but in recent years, its health effects have gained attention. Catechin's primary effects are anticipated for "cancer prevention," "blood sugar inhibition," "controlling seasonal allergies," "alleviating hangovers," and other ailments. Many people are concerned with modern diseases and the like. Tea with high catechin concentration, which is well-known, is permitted by the "Consumer Affairs Agency, Government of Japan" to be labeled as a "Food for Specified Health Use," geared toward people concerned with body fat.

On the contrary, opinions highlighting the risks associated with catechin intake have emerged. In Europe and North America, excessive intake of catechin has been reported to cause liver damage.

Absorption spectrometers are the primary analysis instruments used to determine the amount of catechin in tea, but due to construction restraints based on their measurement principles, they are considerably large-sized instruments (chromatographs and near-infrared light is also used). As a result, quick and easy on-site measurements are impossible. However, since catechins are optically active, it is possible to measure them with a polarimeter. How about implementing a polarimeter onsite for quality control of tea?

(Due to the low concentration of catechin in common tea and tea based beverages, the angle of rotation will also be significantly low.)





## Alcohol

### Luxuries for Mature Tastes

The word "alcohol" applies to many different varieties of liquor that exist throughout the world. The types of alcohol that are most often consumed by Japanese people are beer, wine, sake, distilled spirits, and whiskey. Many people also enjoy vodka, rum, brandy, tequila and the like. These are all luxury fine liquors and their "delightfulness" has come to be of great importance.

Well then, why are alcoholic beverages so delicious? For example, beer and wine taste entirely different. There is no mistaking that flavor is a tremendously important element. Nevertheless, if flavor were the only criteria then people would be satisfied with beverages like tea or juice. In other words, the alcohol contained in liquor is a significantly critical component when it comes to deliciousness.

Taste preferences differ from person to person. There are some people that like sweet drinks, and some people that like dry or sour drinks. Just as every person is different, so too are one's own particular preference for prepared drinks. For instance, there are multitudes of ways to drink whiskey. Drinking whiskey without adding anything is referred to as, "neat." Pouring whiskey over a large chunk of ice and drinking it as it melts is referred to as, "on the rocks." Adding the same amount of water to whiskey is referred to as "twice up" (a popular way of drinking whiskey in Japan). There are many ways to enjoy whiskey, but the majority of people reference alcohol by volume (concentration) labeled on the whiskey bottle as some degree of standards. Alcohol concentration is intimately connected with the sense of the "degree of satisfaction." By measuring the refractive index and Brix, it is possible

to compute the general alcohol concentration. If it is a distilled spirit, which contains little else besides the alcohol, the measurement results will be fairly precise and accurate. For more accurate and precise measurement, or for measuring liqueurs and brewed alcohol that contain other dissolved components apart from alcohol, measuring the angle of rotation is one method.

Take "moromi" (the unfiltered liquid during the fermenting stage of the sake brewing process just before becoming sake; contains ingredients such as yeast starter, koji mold, and steamed rice), for instance. In addition to alcohol, main components of "moromi" contain carbohydrates, and trace amounts of organic acids and amino acids. These components are optically active, whereas alcohol does not have optical activity. Therefore, by measuring the refractive index (Brix) and the angle of rotation, the alcohol content ratio can be estimated in alcoholic beverages.



## Lactose

### Helping to Support Healthy, Lively Bifidobacterium

"Lactose" is a type of sugar found in foods, primarily in milk (cow's milk) and breast milk, which is contained in the milk of all mammals. The Japanese word for lactose is "nyuutou." It is a disaccharide derived from the combination of two sugars, glucose and galactose. Among the types of sugars, lactose has a low level of sweetness (taste-wise); it is only about 15-30% as sweet as sugar and hence has limited value as a sweetening agent. Despite its importance in promoting healthy, lively bifidobacterium, which improve the gastrointestinal environment and keep the intestines healthy, excessive intake of lactose can have a laxative effect. A deficiency of lactase- an enzyme produced in our small intestines, can cause "lactose intolerance." Once mammals pass the nursing period (a stage where nutrients are obtained solely from milk), in nearly every case, lactase activity declines. This symptom is prevalent in in people of Asian descent, but it affects Westerners as well. For this reason, sales of "lactose free milk" and other products are readily available overseas. Soy milk, almond and rice milk

are some examples of lactose free products. Additionally, dairy products where the lactose content is adjusted are available on the market. Measurement and regulation are indispensable for the quality of these products.

Lactose has many other extended applications and is used as a filler in food products and as a diluent in pharmaceuticals. A "diluent" is an additive used to make taking medication easier and more convenient. Furthermore, the use of lactose monohydrate in experiments is standardized within the "Japanese Pharmacopoeia."

The components of lactose are stipulated by the "Japanese Pharmacopoeia" with an angle of rotation of  $[\alpha]_D^{20} = +54.4$  to  $+59.5^\circ$ . Lactose is used in many areas of our lives; from the obvious, ready-to-eat foodstuffs, to the somewhat obscure pharmaceuticals. Is it not essential to measure angle of rotation for quality control?



### Specific Rotation of Lactose

Lactose  $[\alpha]_D^{20} = +54.4$  to  $+59.5^\circ$

Per the Ministry of Health, Labour and Welfare  
"Japanese Pharmacopoeia."



## Collagen

### Skincare Essentials

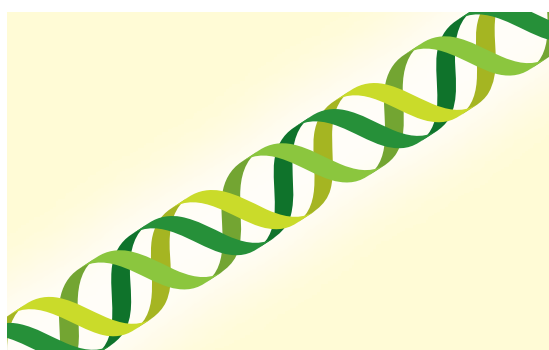
Collagen is an essential structural element that makes up roughly 30% of protein, which forms our bodies. It exists in strategic locations of our bodies. Its elasticity makes our tendons, bones, and cartilage strong and robust. Moreover, it keeps our skin in a healthy state. Collagen is utilized in various products. From products that come in contact with our skin, such as soap, skin toner, milky lotion, cream, liquid foundation, shampoo, to products that we consume, such as flavorings, dressings, energy drinks, and tablet supplements, collagen is actively involved across a wide range of areas.

So then, why on earth do manufacturers use collagen in each and every one of their products? Well, collagen is used to add value to their products. This "added value" is "health" and "beauty;" things which many people will always have an interest in, regardless of the times. For consumers seeking health and beauty, "collagen" is a

key word that is incredibly alluring. Thus, measuring the amount of collagen contained in a product is an absolute must.

Collagen is formed as a special structure called a "triple helix." By applying a specific heat to this structure, it unravels, denatures, and becomes gelatinized. The triple helix structure is optically active, and its optical rotation can be measured using a polarimeter. Similarly, collagen's refractive index is also frequently measured.

Temperature control is important for measuring collagen and therefore ATAGO recommends **the AP-300's package A**, or **the SAC-i series** and jacketed flow tubes, circulating constant temperature water baths and other optional accessories for temperature control (refer to pg. B20 to B21).



Triple helix



## Feed

### For a Safe and Healthy Diet

Humanity's life is supported and maintained by livestock (domestic animals). Since ancient times, long before recorded history, many different species of animals have lived alongside us as a source of labor and food. In modern Japan, instead of "livestock," the term "industrial livestock" (economy livestock) is taking hold. As is evident from the name, not only do livestock support each and every one of our lives, but they also bring us industrial and economical profit.

Creating and maintaining good living conditions in which health and welfare of the livestock is accommodated is vital for greater profit. This is why feed with high nutritional value is absolutely crucial.

Among the nutrients that are indispensable to livestock, there are some that cannot be synthesized from consuming feed and food obtained from nature. These nutrients must be supplemented with additives. The Ministry of Agriculture, Forestry and Fisheries "Ordinance Concerning Component Standards for Feed, As Well As Feed Additives;" stringently regulates every aspect from the inspection criteria to the method of feed additives-smell, taste, refractive index and viscosity.

The angle of rotation is quite relevant to these standards and polarimeters are required for ingredient analysis. Polarimetry measuring method explicitly states that "Excluding cases with separate stipulations, measurement shall be performed at a temperature of 20°C, with an observation tube of 100mm, and with the D-line of the sodium spectrum."

In recent years, an enormous quantity of feed is imported

to Japan from overseas. Upon arrival, a highly precise and effective inspection must be conducted. High quality feed and additives also face a high level of scrutiny overseas, with regulations becoming even stricter in the EU and the US. It is reported that in the coming years, the market will expand and in the year 2018, feed additives will be a 175 billion (US) dollar global industry. Moreover, per establishing and strengthening the "branding" of certain breeds of livestock, there has been an increase in those seeking high quality animals. Surely, measuring feed and additives with a polarimeter is an integral part of ensuring a safe and delicious diet, thereby providing livestock with a rich and plentiful life.

### Specific Rotation of Feed Additive

Arabinose	$[\alpha]_D^{20} = -103 \text{ to } -105^\circ$
Xylose	$[\alpha]_D^{20} = +18.0 \text{ to } +20.0^\circ$
Digitonin	$[\alpha]_D^{20} = -47 \text{ to } -49^\circ$
Cellobiose	$[\alpha]_D^{20} = +34 \text{ to } +35^\circ$
Melibiose	$[\alpha]_D^{20} = +141.2 \text{ to } +141.8^\circ$
Raffinose	$[\alpha]_D^{20} = +122 \text{ to } +124^\circ$

Par the Ministry of Agriculture, Forestry and Fisheries  
"Ordinance Concerning Component Standards  
for Feed, As Well As Feed Additives."





## Food Additives

### Indispensable for the Modern Diet

Food additives refer to substances such as preservatives, sweeteners, food coloring, and fragrances. They are added in food manufacturing and throughout various stages of the process to bring out and improve the flavor, fragrance, appearance, and mouthfeel of a finished product, to fortify nutrients, or to preserve the product.

Component regulations and standards for use are stipulated to ensure the safety of food additives. In Japan, standards are determined by the Ministry of Health, Labour and Welfare. Internationally, JECFA (FAO/WHO Joint Expert Committee on Food Additives) evaluates risk factors such as toxicity, carcinogenicity, and teratogenicity, calculates the maximum intake that will not harm the body, and determines standards. In Japan, food additives are largely classified into 4 different categories. The first category consists of "Specified Additives." Additives that have been specified, as well as evaluated for their safety belong to this group. Ascorbic acid and xylitol fall under this category.

The second category is "Existing Additives." This is a category of additives that have a long food history in Japan, whose use is permitted without receiving specification. Additives such as gardenia pigment and persimmon tannin belong to this category.

The third category is called the "Natural Fragrances." They consist of natural substances obtained from plants and animals used primarily in applying fragrance to foods, such as vanilla essence and crab essence.

The fourth and final category is called, "General Food and Beverage Additives." These are additives which are generally consumed as food and beverage and also used as additives.

Some examples are strawberry juice and agar.

Food additives are indispensable for the modern diet. For example, imagine that you ate toast with butter and jam and ham for breakfast. The bread used to make toast contains additives like emulsifiers and preservatives. Color fixatives, flavorings, and preservatives are generally used in ham.

Now, let's take a look at miso soup, which is a dish that Japanese-style meals cannot do without. Coagulants, defoamers, and improving agents are generally used in tofu. As for miso, flavorings, preservatives, bleaching agents, and reinforcing agents are used.

In recent times, food safety has become a serious matter. There are many people that are placing great importance on the safety of food additives. Of course, this doesn't mean that there are issues concerning the safety of all food additives. There are additives used during the food manufacturing process, and food additives that do not remain in the final product. There are also lots of food additives used that are not written on the ingredients list of food products. In these times, it is difficult to try and eat only additive-free foods, and it's not necessarily the case that additive-free foods are the absolute best.

When it comes to food additives, standards for the refractive index, as well as for the specific rotation for every food substance, are partially designated. In addition to our high accuracy refractometers and polarimeters, ATAGO also recommends **the Refracto-Polarimeter, RePo-5**. It is an inexpensive, integrated unit that measure "refractive index + angle of rotation."



### L-Ascorbic acid (Vitamin C)

L-Ascorbic acid, the official name for "vitamin C," is a kind of water soluble vitamin. It is a powdered substance that appears either as white or slightly yellow crystals. It is odorless with a sour taste. Standard values such as a purity of 99.0% and above, and a specific rotation of  $[\alpha]_D^{20} = +20.5$  to  $+21.5^\circ$  are stipulated in the "Food Additives Codex." Its primary applications include being used in

beverages, wine, ham, sausage, and as an antioxidant in various foods such as pickles. Under the "Food Additives Codex," it is designated that it must be measured using water as a solvent, dissolved to 10% concentration (10g/100mL). Proper quality control with a polarimeter is demanded.



### L-Threonine

Threonine is an essential amino acid that cannot be synthesized in the human body. It is found in grains such as rice and wheat, but due to the meager amount and poor absorption rate, it is necessary to obtain it from fish, meat, beans, and other food groups. Foods that contain a large amount of threonine include bonito, poultry, and lentils. As a flavoring and additive, chemically synthesized L-Threonine is used for a number of purposes, beginning

with fortifying grains. As in humans, livestock are also unable to synthesize threonine. By adding L-Threonine produced via fermentation to feed, we can expect to improve their amino acid balance, as well as enhance their productivity. In regards to L-Threonine's quality standards, the specific rotation is regulated as  $[\alpha]_D^{20} = +26.0$  to  $+29.0^\circ$ .



### Calcium gluconate hydrate

Calcium gluconate is regulated by the "Japan Pharmacopoeia" as a pharmaceutical. Among the calcium compounds, it dissolves easily in water and it is an ideal calcium fortifier used in manufacturing liquids such as beverages and energy drinks. It's praised for its ability to

improve tetany related symptoms caused by hypocalcemia and for its benefits and effects as a food additive such as a calcium supplement for celiac disease in infants. The specific rotation of calcium gluconate hydrate is  $[\alpha]_D^{20} = +6$  to  $+11^\circ$ .



## Pharmaceutical & Medical

### Preventing the Progression of Modern Disease & Signals from the Body that Cannot be Overlooked

"Pharmaceuticals" refer to medicines that are used in the prevention, diagnosis, and treatment of diseases in humans and animals. There are many different varieties of pharmaceuticals. They have been studied, researched and developed to fit people's needs. There are drugs that are taken orally, applied to the skin, and injected directly into the bloodstream. Even taking only oral medicine into account, there are numerous ways that have been devised to facilitate ease of swallowing, such as taste, size, shape, material quality and texture.

The effectiveness of pharmaceuticals is fully demonstrated when preventing the disease, or the onset of a disease. The majority of various substances that make up pharmaceuticals possess optical activity, so it can be said that the pharmaceutical manufacturing industry is the typical example of a field where polarimeters are used the most. Measurement of the angle of rotation has long since been performed in the pharmaceutical manufacturing industry in order to distinguish the properties of medicine. For this reason, a system is in place for such procedures stipulated by the "Japan Pharmacopoeia," per article 41 of the Pharmaceutical Affairs Law.

Standards for specific rotation for every substance are written in the "Japan Pharmacopoeia." They are important inspection criteria for quality control. For some substances, not only are there regulation standards for specific rotation, but refractive index standards are included as well.

The majority of pharmaceutical companies follow these standards for measuring the angle of rotation.

In many cases, due to the properties of pharmaceuticals, refractive index and angle of rotation are often measured at high accuracy. However, if high accuracy isn't necessary, ATAGO has an inexpensive, integrated unit that can measure "refractive index + angle of rotation," especially tailored for general-purpose use. An instrument that can measure both refractive index and angle of rotation in a single unit has finally become true: **the Refracto-Polarimeter, RePo-5**. It is a portably designed size that fits in the palm of your hand, allowing users to take measurements anywhere, as with other general inspection methods.

Additionally, other than pharmaceuticals, food additives have specific standards for the refractive index, as well as for the specific rotation for most substances. Refractive index and angle of rotation measurement is also performed in this field.



### Epinephrine

Many people have probably heard of the word, "epipen" (epinephrine autoinjector). An epipen is a medical device used as an adjuvant treatment to mitigate the progression of anaphylaxis symptoms. Anaphylaxis is an acute, systemic, as well as severe type of allergic reaction. In many cases, it is caused by bee venom, food, and drugs. It is known to trigger a life-threatening reaction (anaphylactic shock). Patients that are highly prone to

anaphylaxis normally carry an epipen on-hand. In the event of an outbreak, the epipen is used to alleviate symptoms until they can be transported to a medical facility. After the epinephrine (adrenaline) is dried, it is dissolved in a hydrochloric acid reagent and measured. The specific rotation is  $[\alpha]_D^{20} = -50$  to  $-53.5^\circ$ .



### Dextran

Dextran is a major substance used in intravenous therapy (transfusion). It is effective as an initial treatment when acute massive blood loss occurs. It is also used to reduce the amount of blood transfusion during surgery. It is used to prevent a drop in blood pressure when the blood circulating throughout the body decreases for some sort of reason. Another name for it is, "Ringer's

lactate solution." The blood concentration is diluted with dextran and thinned, making it easier to flow and reach the capillaries, improving overall blood circulation. Dextran is a polysaccharide made of many glucose molecules, and lactobacillus produced from sucrose. The angle of rotation is measured by using solid dextran and dissolving it in water prior to measurement.



### Thalidomide

There is an optically active substance, notorious for setting off public anxiety: the chemical compound "thalidomide." It is well-known for being contained in sleeping pills and digestive medicines that were sold during the 1950's to the 1960's, however, due to its teratogenicity, it was recalled and pulled off the market. Thalidomide is a racemic mixture of an (R) enantiomer and an (S) enantiomer. After becoming

a topic of public concern, it was reported that only the (R) enantiomer possessed sleep-inducing effects and only the (S) enantiomer expressed teratogenicity. Subsequent research found that even if only the (R) enantiomer was administered, it racemizes within the body. Although thalidomide generated many reports of these damaging health effects, recently, it has been approved for its capacity to be used as a treatment for Hansen's disease (leprosy).



## Industrial Field

### The Possibility of New Measurement Standards

There are many kinds of oil solutions used in the industrial field. For example, when metal is shaved and formed, cutting oil is used to make the machining process easier by mitigating the friction produced between the machine blade and the metal workpiece. Lubricating oil is used to cool and smooth the surface of a cog, in order for it to rotate properly and efficiently.

In fact, there are a variety of industrial oils, not just the aforementioned cutting oil and lubricating oil. There are release agents, corrosion inhibitors, cleaning solutions, hydraulic fluids, quenching oils, and the like. The common trait they share is that they are all used in order to make industrial machinery operate smoothly and properly. Although the refractive index of these fluids is measured quite frequently, however, angle of rotation is rarely measured. The reason behind this is that most oil solutions are not optically active. Nevertheless, it is often the case that even when solutions are optically active the coloration and high viscosity make them incompatible with the measurement conditions for angle of rotation. To measure the angle of rotation, light must be passed through a sample, therefore, the coloration and viscosity interferes with the proper amount of light to pass through.

**The RePo Series** can measure with an extremely small amount of sample, much smaller than the amount required by conventional polarimeters. This means that the distance that the light travels is shorter. In other words, even if a sample is viscous and has coloration, there is a great possibility that it can be measured. Recent research and development of biotechnology has led to an increase in the

variety of industrial oil solutions. For these solutions, angle of rotation may potentially become the new measurement standard.

#### Turpentine

Turpentine is also called "oil of turpentine," "wood turpentine," and "spirit of turpentine." It is a refined oil obtained from steam distillation of pine resin. It is used as a solvent for paint and varnish, and in the art industry for thinning oil based paints. It has an angle of rotation which can be measured with a polarimeter in order to distinguish the origin of the turpentine.

#### Starch

Starch is a carbohydrate (polysaccharide), primarily sourced from corn, wheat, potatoes, tapioca, and the like. In Japan, "katakuriko" (dogtooth violet starch; it has largely been replaced with starch from potatoes, but it is still called katakuriko) and cornstarch are probably the most well-known. Although it is mainly used in saccharified products (products made from converting starch into sugar) food products, and as feed, it also has a wide variety of industrial uses such as in cardboard and paper manufacturing, as well as in bioplastics and as an adhesive. In Europe and in many countries, the measurement method for the angle of rotation and specific rotation as written in the "ISO 10520 Native starch-Determination of starch content-Ewers polarimetric method" is used as the standard.

## Specific Rotation List

Material name	Solvent	Specific rotation		Material (g)	Solution (mL)
		[α] Minimum	[α] Maximum		
Ascorbic acid	Water	+20.5	+21.5	2.5	25
L-aspartic acid	6mol/L Hydrochloric acid reagent	+24.0	+26.0	2	25
Epinephrine	1 mol/L Hydrochloric acid reagent	-50.0	-53.5	1	25
Ephedrine hydrochloride	Water	-33.0	-36.0	1	20
Ergotamine tartrate		-155	-165		
Kainic acid hydrate	Water	-13	-17	0.5	50
d-camphor	Ethanol (95)	+41.0	+43.0	5	50
Cocaine hydrochloride	Water	-70	-73	0.5	20
Cortisone acetate ester	Methanol	+207	+216	0.1	10
Cholecalciferol	Ethanol (95)	+103	+112	0.05	10
Cholesterol	1,4-Dioxane	-34	-38	0.2	10
Santonin	Chloroform	-170	-175	0.2	10
Digitoxin	Chloroform	+16	+18	0.5	20
Clove oil		0	-1.5	0	0
Testosterone enantholactam acid ester	1,4-Dioxane	+77	+88	0.1	10
Deslanoside	Anhydrous pyridine	+6.5	+8.5	0.5	25
Dehydrocholic acid	1,4-Dioxane	+29	+32	0.2	10
L-threonine	Water	-26.0	-29.0	1.5	25
Peppermint oil		-17.0	-36.0		
Calcium pantothenate	Water	+25.0	+28.5	1	20
Hydrocortisone acetate ester	1,4-Dioxane	+158	+165	0.05	10
L-phenylalanine	Water	-33.0	-35.5	0.5	25
Prednisolone	Ethanol (95)	+113	+119	0.2	20
Maltose hydrate	Ammonia reagent and water	+126	+131	10	100
Methamphetamine hydrochloride	Water	+16	+19	0.2	10
l-menthol	Ethanol (95)	-45.0	-51.0	2.5	25
dl-menthol	Ethanol (95)	-2.0	+2.0	2.5	25
L-lysine hydrochloride	6mol/L Hydrochloric acid reagent	+19.0	+21.5	2	25
Anhydrous lactose	Water	+54.4	+55.9		
Purified sucrose	Water	+66.3	+67.0	26	100

Per the Ministry of Health, Labour and Welfare "Japanese Pharmacopoeia"

# What is Light?

Is it a particle or a wave? Is it both, or perhaps neither? Light possesses the properties of both particles and waves. It's a phenomenon that can't be fully explained simply by addressing whether it's a particle or a wave.

Light has long since fascinated people, and it has plagued many scientists in their attempts to unravel its mysteries.

Optical rotation is one phenomenon of light, where light passes through a substance and depending on the substance, the light rotates.

Substances and compounds which contain properties that cause light to rotate are called "optically active" substances. Light rotates to the right or to the left, as well as at various angles, depending on the substance. We can discover certain things about a particular substance from its angle of rotation. Polarimeters are used to measure angle of rotation.

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**HACCP GMP GLP**

ATAGO products comply with HACCP, GMP, and GLP system standards.

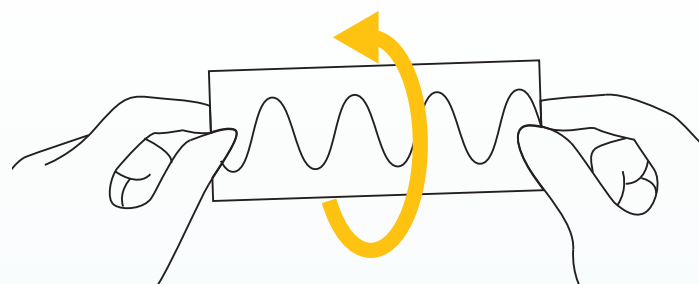
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\* Specifications and appearance are subject to change without notice.

## Measurement Principles

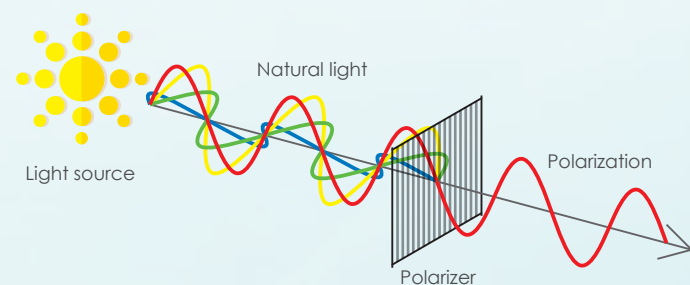
Light exhibits a "wavy" quality, in which it oscillates as it moves along. When this wavy light passes through a substance, a phenomenon occurs wherein the direction of the undulating, wavy light rotates. This is the optical rotation of light.

Using this as a basis, let's try to explain optical rotation with an easy to understand, metaphorical illustration. Draw a wavy line on a long piece of paper. Hold the center of both ends of the piece of paper firmly with your fingers. Turn it around at all sorts of angles. This oscillating wave that moves in the direction of many angles, which is a deeply complicated phenomenon entangled with other matter is natural light. It is the normal state of light.



The angle of rotation of light can't be measured in this state. The oscillating waves of light move at each and every angle, so it is impossible to determine which wave passes through a substance and to what degree it rotated.

As such, this light that moves at many angles and oscillates as it travels along must be limited to move in the direction of one angle. In order to achieve this, light is passed through something called a "polarizer." A polarizer has a grid-like pattern, arranged in an intricate, alternating fashion of lines that light does not pass through and spaces that light passes through. The light is obstructed by the polarizer which enables only a single wave of light moving at one angle to pass through. This is called "polarized light."



When two polarizers are placed one after the other and only one is made to rotate, this creates an angle that completely blocks out the light. This is because the light, which has passed through the first polarizer and has been constricted down to a single wave moving at one angle, is blocked by a second polarizer of a different angle.

By rotating the polarizer (the second polarizer in a polarimeter is called an "analyzer") and finding the angle at which the polarized light passed through, or the angle at which it was blocked, it is possible to measure the angle at which the light passed through a substance (the angle of rotation). Polarimeters use this principle to measure the angle of rotation of a substance.

## Polarimeters

Polarimeters are instruments used for measuring the angle of optical rotation of light. General polarimeters contain mechanisms such as a light source and polarizer. Light emitted from the light source passes through the polarizer and the angle of the wave of light is restricted. The angle at which the light rotates is measured when it passes through the substance.

During measurement, if the plane of vibration which faces the light source appears to be rotating clockwise, it is dextrorotatory. If it appears to rotate counter-clockwise, it is levorotatory. "Dextrorotatory" comes from the Latin word "dextro" meaning, "right." "d-rotary" can also be used to refer to dextrorotatory. "Levorotatory" comes from the Latin word "levo" meaning, "left." Levorotatory is also known as "l-rotatory. The system for denoting optical isomers (enantiomers), either d- or l-, is derived from these words.

Polarimeters are largely used in the sugar refining and pharmaceutical industries. In the sugar refining industry, polarimeters are used to determine the type of sugar or to ascertain the purity. In the world of pharmaceuticals, there are many cases where chemical compounds may be subjected to certain standards, depending on the angle of rotation. Polarimeters are used to perform checks such as determining the type of substance.

### Polarizers for Everyday, Practical Use

In regards to polarimeters, when it comes to the optical rotation of light, "polarizers" sound like a difficult concept that's hard to imagine. However, polarizers are surprisingly used in various places throughout everyday life.

#### •Cameras

Polarizing filters for camera lenses are a must in order to take pictures that come out exactly how you'd like.



#### •Polarized sunglasses

Many of us have experienced being blinded by the glaring brightness of the outdoors when on a snowy mountain, doing water sports, or fishing. Polarizing film controls reflected light from the surface of snow and water, and allows only the necessary amount of light to penetrate. It is commonly used in these types of leisure activities and sports.



#### •LCDs

LCDs have two polarizers (polarizing filters). In order to display a clear, vivid image, they control the light which passes in various directions to produce light that passes in only one uniform direction.



# Two Points of Consideration

## Is that level of accuracy really necessary?

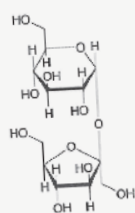
There are two critical elements to accuracy: "precision" and "repeatability." The angle of rotation of products such as food additives and medicine is often measured at low concentrations. As the resulting angle of rotation values are also low, high accuracy levels are necessary. Nevertheless, seeking excessively high accuracy levels can lead to predicaments such as "troublesome, complicated measurement" and "heavily investing and sinking money in a polarimeter." This is not a very desirable situation.

Every substance has a standard for specific rotation, as designated in the "Japanese Pharmacopoeia and Food Additives Official Codex." This standard is written as a range of " \_ \_ ° to \_ \_ °." In other words, as long as the value falls within this range, it's perfectly acceptable. For example, the range for sucrose (white soft sugar) is 65.0 to 67.0°, and the range for l-menthol is -45.0 to -51.0°. Of course, it will vary according to the substance, but this range is surprisingly wide.

Therefore, it's not necessary to seek excessively high accuracy levels. ATAGO has a number of polarimeter models. Please select the model best suited to your needs, after considering the accuracy level and management range needed, and taking into account operational usability and convenience.

Excerpt from "The Japanese Pharmacopoeia, sixteenth edition." The circled sections contain information about angle of rotation.

### 白糖 White Soft Sugar



$C_{12}H_{22}O_{11}$  : 342.30  
β-D-Fructofuranosyl α-D-glucopyranoside  
[57-50-1]

性状 本品は無色又は白色の結晶又は結晶性の粉末で、においはなく、味は甘い。

本品は水に極めて溶けやすく、エタノール(95)に極めて溶けにくく、ジエチルエーテルにほとんど溶けない。  
本品の水溶液(1→10)は中性である。

#### 確認試験

- (1) 本品1gを加熱するとき、融解してふくれ上がり、カラメルのおおいを産して、かさ高い炭化物となる。
- (2) 本品0.1gに希硫酸2mLを加えて煮沸し、水酸化ナトリウム試液4mL及びフェーリング試液3mLを加えて煮沸するまで加熱するとき、赤色～暗赤色の沈殿を生じる。

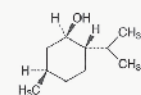
旋光度 (2.0)  $[\alpha]_D^{20}$  : +65.0 ~ +67.0°(乾燥後, 13g, 水, 50mL, 100mm).

#### 純度試験

(1) 溶状 本品100gを水100mLに溶かし、この液50mLをネスラー管にとり、白色の背景を用い側方から観察するとき、液は無色又はわずかに黄色で、青色を呈しない。更にこの液をネスラー管に充填し、密栓して2日間放置するとき、沈殿を生じない。

(2) 塩化物 (1.03) 本品10.0gを水に溶かし100mLとし、試料溶液とする。この液20mLに希硝酸6mL及び水を加えて50mLとする。これを検液とし、試験を行う。比較液には

### l-メントール l-Menthol



$C_{10}H_{20}O$  : 156.27  
(1R,2S,5R)-5-Methyl-2-(1-methylethyl)cyclohexanol  
[2216-51-3]

本品は定量するとき、l-メントール( $C_{10}H_{20}O$ )98.0%以上を含む。

性状 本品は無色の結晶で、特異で爽快な芳香があり、味は初め舌をやくようで、後に清涼となる。

本品はエタノール(95)又はジエチルエーテルに極めて溶けやすく、水に極めて溶けにくい。

本品は室温で徐々に昇華する。

#### 確認試験

- (1) 本品を等量のカンフル、抱水クロラルール又はチモールとすり混ぜるとき、液化化する。
- (2) 本品1gに硫酸20mLを加えて振り混ぜるとき、液は混濁して黄赤色を呈するが、3時間放置するとき、メントールのにおいのない澄明な油層を分離する。

旋光度 (2.0)  $[\alpha]_D^{20}$  : -45.0 ~ -51.0°(2.5g, エタノール(95), 25mL, 100mm).

融点 (2.60) 42~44°C

#### 純度試験

(1) 蒸発残留物 本品2.0gを水浴上で蒸発し、残留物を105°Cで2時間乾燥するとき、その量は1.0mg以下である。

(2) チモール 本品0.20gをとり、酢酸(100)2mL、硫酸6滴及び硝酸2滴の冷混液を加えるとき、液は直ちに緑色～青緑色を呈しない。

(3) ニトロメタン又はニトロエタン 本品0.5gをフラスコにとり、水酸化ナトリウム溶液(1→2)2mL及び過酸化水素(30)1mLを加え、還流冷却器を付け、10分間穏やかに煮沸させる。冷後、水を加えて正確に20mLとし、ろ過する。ろ液1mLをネスラー管にとり、水を加えて10mLとし、希硫酸

## Are temperature control features really necessary?

### Angle of Rotation

Depending on the temperature, the angle of rotation changes slightly. Most substances express angle of rotation at 20.0°C. Consequently, measurements must be taken at a constant, controlled temperature for accurate and precise angle of rotation measurement. There are two methods for temperature control: ① circulating constant temperature water around the outside of the observation tube, and ② maintaining a constant temperature of the section where the observation tube is placed. Method ① is the most common, the liquid inside the observation tube quickly and completely reaches a constant temperature and stabilizes. Observation tubes compatible with method ② are available at ATAGO. Now, this will be expounded upon later, but if stringent accuracy levels are not needed for angle of rotation measurement values (the value of the converted specific rotation), it is possible to maintain the room temperature where the polarimeter is placed at about 20°C. For reference, the specific rotation of sucrose changes 0.0313° per 1°C. Under the Japanese Pharmacopoeia, the standard specific rotation range for sucrose (white soft sugar) is 65.0 to 67.0°C. Hence, even if the measurement temperature deviates slightly from 20°C, it's not a serious problem in terms of management.



Unjacketed Flow Tube

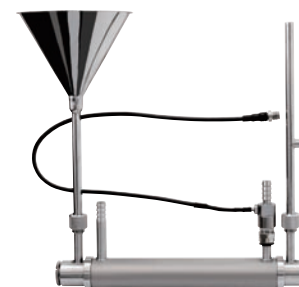


Circulating Constant Temperature Bath 60-C5

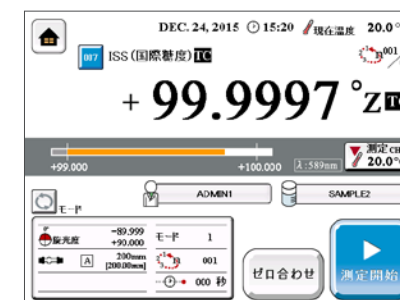
## International Sugar Scale and Purity

In the sugar refining industry, measurement values for the International Sugar Scale (ISS) and Purity are expressed at 20.0°C. Circulating water at a constant temperature of 20°C around the outside of the observation tube and measuring is widely practiced in this field. Compatible observation tubes for this measurement method are available at ATAGO.

On the one hand, in regards to the International Sugar Scale and Purity, since the measurement sample for these scales is limited to sucrose, it is possible to adjust values based on the International Sugar Scale value changes in response to temperature. Simply put, even when measuring at a temperature other than 20°C, International Sugar Scale values at 20.0°C can be displayed. ATAGO's AP-300, SAC-i, and SAC-i 589/882 are equipped with dual scales of ISS (without temperature compensation) and ISS (TC) (with temperature compensation). The Purity scale also features temperature compensation. Furthermore, the RePo-1's ISS and Purity scales also come with temperature compensation. A temperature compensation table based on the ICUMSA (International Commission for Uniform Methods of Sugar Analysis) standards for the International Sugar Scale measurement of sucrose at 18 to 30°C is included. By efficiently using temperature compensation, you can avoid the hassle of using circulating constant temperature water.



Jacketed Flow Tube



International Sugar Scale Measurement Screen

# Polarimeter Terminology

## Angle of Rotation

Optical rotation is a phenomenon wherein light vibrating in one fixed direction (polarized light) passes through a liquid sample and rotates. The point at which it tilts is called the "angle of rotation." It is the basic value measured with a polarimeter. The angle of rotation changes depending on the concentration of the liquid sample, the length of the observation tube, the temperature, and the measurement wavelength. The unit is expressed as, "°."

## Specific Rotation

Specific rotation is a characteristic value related to optical activity, standardized for each and every substance. There are set values determined for every substance, printed in literature such as chemistry handbooks. As a definition, it corresponds with the angle of rotation of a sample at 100% concentration measured with a 100mm observation tube. The unit is expressed as, "°."

⇒ **specific rotation = (10000 × angle of rotation) / (length of observation tube (mm) × concentration (g/100mL))**

## Concentration

The density of a solution made when dissolving an optically active substance in optically inactive water and alcohol is called "concentration." The unit is expressed as, "g/100mL."

⇒ **concentration (g/100mL) = (100 × angle of rotation (measurement value obtained with a polarimeter)) / (length of observation tube (dm) × specific rotation)**  
\* 1dm = 10cm

## International Sugar Scale

A scale converted from the angle of rotation. The unit is expressed as, "°Z." 26g/100mL of sucrose solution measured with a 200mm observation tube at 20°C is 100°Z. This scale is used in the sugar refining industry. As with the Brix scale for sugar level, temperature compensation is necessary. Sucrose solution of 100°Z is 23.70% Brix.

⇒ **International Sugar Scale = angle of rotation × 2.888**

## Purity

Purity is the proportion of the amount of sucrose contained in the total soluble solid content. Brix value is required for Purity measurement.

The unit for Purity is expressed as, "%."

⇒ **Pol = (26.016/100mL of mass (density)) × International Sugar Scale**

\* sucrose amount is referred to as "Pol."

⇒ **Purity = (Pol/Brix) × 100**

## OD

OD refers to "optical density." It is also called, "absorbance." For a given wavelength of light, supposing the transmittance of water is 100%, OD of 10% is 1.0, transmittance of 1% is OD of 2.0, and for transmittance of 0.1%, the OD is 3.0. In regards to polarimeters, OD illustrates the densest darkly colored liquid that is capable of being measured.

## ICUMSA

(International Commission for Uniform Methods of Sugar Analysis)

Known as the "International Sugar Analysis Standardization Committee" in Japanese, ICUMSA is an international organization unifying the activities of sugar analysis committees from several countries.

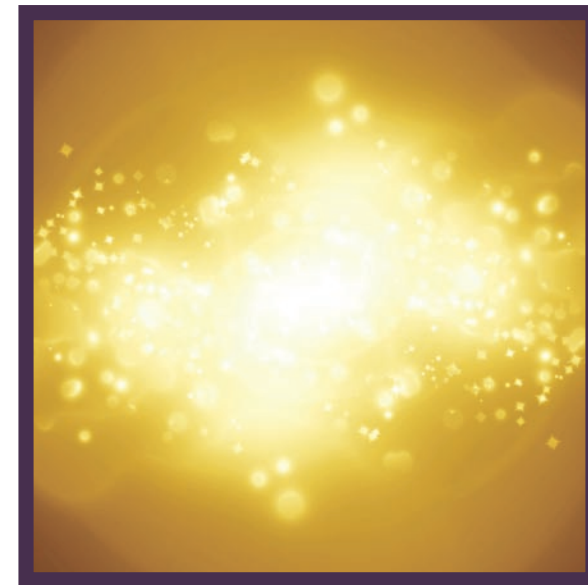
## Measurement Wavelength(λ)

The angle of rotation will change depending on the wavelength of the light source used by a polarimeter. Almost all polarimeters use the Sodium D-line wavelength of 589.3nm. The SAC-i 589/882 is capable of measurement not only at 589nm, but it can also be changed to measure at a wavelength of 882nm.

## Observation Tube

Most polarimeters measure angle of rotation by filling the inside of tubes, called observation tubes, with liquid sample and passing light through them. Observation tube lengths of 100mm and 200mm are the most prevalent. 200mm observation tubes are primarily used in the sugar refining industry, and 100mm observation tubes are largely used in the pharmaceutical industry. There are also short-type observation tubes of lengths such as 10mm.

\* RePo series does not use observation tubes.



# Polarimeter Lineup

From models suited to the sugar refining and pharmaceutical industries, to the newest, state-of-the art portable models, ATAGO's polarimeters meet a number of demands.

Automatic Polarimeter / Saccharimeter

# SAC-i

Cat.No.5951

# SAC-i 589/882

Cat.No.5952



ICUMSA  
compliant

FDA 21  
CFR Part11  
compliant

## Specifications

	SAC-i	SAC-i 589/882
Measurement Accuracy * Checked by reading a standard quartz plate.	AR: $\pm 0.002^\circ$ (-5.0 to +5.0°) $\pm 0.005^\circ$ (-45.0 to -5.0°, +5.0 to +45.0°) ISS: $\pm 0.015^\circ Z$ (-130.0 to +130.0°Z) [Other ranges] AR: $\pm 0.010^\circ$ ISS: $\pm 0.030^\circ Z$	589nm: AR: $\pm 0.002^\circ$ (-5.0 to +5.0°) $\pm 0.005^\circ$ (-45.0 to -5.0°, +5.0 to +45.0°) ISS: $\pm 0.015^\circ Z$ (-130.0 to +130.0°Z) [Other ranges] AR: $\pm 0.010^\circ$ ISS: $\pm 0.030^\circ Z$ 882nm: AR: $\pm 0.002^\circ$ (-5.0 to +5.0°) $\pm 0.005^\circ$ (-19.3 to -5.0°, +5.0 to +19.3°) ISS: $\pm 0.015^\circ Z$ (-130.0 to +130.0°Z) [Other ranges] AR: $\pm 0.010^\circ$ ISS: $\pm 0.070^\circ Z$
Repeatability	AR: $\pm 0.003^\circ$ ISS: $\pm 0.009^\circ Z$	—
Measurement Wavelength	589nm (equivalent to the sodium-D line spectrum)	589nm (equivalent to the sodium-D line spectrum), 882nm (near infrared ray)
Light Source	LED: 589nm interference filter	LED: 589nm interference filter, 882nm interference filter

## Common Specifications

Measurement Readings	AR, ISS (without temperature compensation), ISS (with ATC), SR, Conc, Purity, User scale, AR of Quartz Plate (with ATC), and Temp (°C/°F)
Measurement Range	AR: -89.9999 to +90.0000°, -359.9999 to +360.0000° ISS: -259.0000 to +259.0000°Z
Resolution	AR: 0.0001° ISS: 0.0001°Z Temperature: 0.1°C/0.1°F
Temperature Compensation Range	10 to 40°C
Temperature Display Accuracy	$\pm 0.2^\circ C$
Ambient Temperature	Use the instrument where the temperature is between 10 to 40°C
Display Panel	7.5-inch color LCD + touch screen
Printer Output	Digital printer DP-AD / DP-63 (sold separately) Output method: RS-232C (9 pin D-Sub male connector)
Data Output To USB Flash Drive	CSV text file format
Communication With Computer	Communication via: USB-Serial
Observation Tube Included	200mm (10mL) $\times$ 1, 100mm (5mL) $\times$ 1
Power Supply	AC100 to 240V, 50/60 Hz
Power Consumption	140VA
Dimensions & Weight	60 $\times$ 36.5 $\times$ 21cm, 20kg (Main Unit only)

Reference: AR = Angle of Rotation, SR = Specific Rotation, ISS = International Sugar Scale, Temp = Temperature, Conc = Concentration, RI = Refractive Index, ATC = Automatic Temperature Compensation

## Touchscreen for Enhanced Operability

Automatic measurements are digitally displayed in a mere 12 seconds. Simply insert the observation tube and press START (4 seconds when using high-speed continuous measurement mode). Repeatable accuracy of angle of rotation is  $\pm 0.003^\circ$ , and  $0.009^\circ Z$  for International Sugar Scale. Capable of displaying a resolution of up to 4 decimal places.



Measurement screen with setting sub-window (lower left)

### Compatible with wavelength of 882nm

By replacing the optical unit, the SAC-i 589/882 is capable of measuring at both wavelengths of 589nm and 882nm.

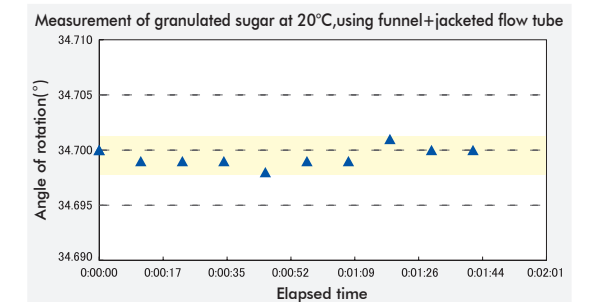


### Refractometer RX- $\alpha$ /i Series connectivity

Capable of connecting to the Digital Refractometer RX- $\alpha$ /i Series. Direct data transfer of Brix values and automatic calculation and display of Purity has been made possible.

### Improved stability of liquids

Even more stable measurements are now possible through a complete performance upgrade and revamp of the measurement method of ATAGO's own original measurement engine system. Measurement of sample types that are conventionally difficult to measure has now been made easier, virtually eliminating instrument errors.



**SAC-i Special Packages** SAC-i (main unit) can be purchased independently. Custom special package is available. Contact ATAGO for details.

#### Type A Temperature Control

Recommended for  
Sugar Industry

Cat.No.5961

- SAC-i (including accessories)
- Jacketed flow tube with funnel (200mm-approximate volume 15mL)

\*Circulating Constant Temperature Bath 60-C5 (Cat.No.1923) sold separately

#### Type B No Temperature Control

Recommended for  
Sugar Industry

Cat.No.5962

- SAC-i (including accessories)
- Unjacketed flow tube with funnel (200mm-approximate volume 15mL)

#### Type C Temperature Control

Recommended for  
Pharmaceutical Industry

Cat.No.5963

- SAC-i (including accessories)
- Jacketed flow tube (100mm)
- Quartz Control Plate (8°, 17°, or 34°)
- Digital printer DP-AD • Printer paper for DP-AD
- Ribbon cassette for DP-AD
- Circulating Constant Temperature Bath 60-C5 (Cat.No.1923)

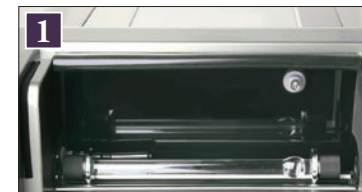
#### Type D No Temperature Control

Recommended for  
Pharmaceutical Industry

Cat.No.5964

- SAC-i (including accessories)
- Quartz Control Plate (8°, 17°, or 34°)
- Digital printer DP-AD
- Printer paper for DP-AD
- Ribbon cassette for DP-AD

## Measurement Method



### 1 Insert the sample

Place the sample into the observation tube and insert it into the sample chamber.



### 2 Start

Close the lid and press START to begin measurement.



### 3 Result display

Measurement values will be displayed.



Automatic Polarimeter

# AP-300

Cat.No.5291



ICUMSA compliant

FDA 21 CFR Part 11 Software Included in Standard Delivery.

## Specifications

Measurement Scale	AR, ISS (without temperature compensation), ISS (ATC)
Measurement Readings	AR, ISS (without temperature compensation), ISS (ATC), SR, Conc, and Purity
Measurement Range	AR : -89.999 to +89.999° ISS : -130.000 to +130.000°Z Temp : 10.0 to 30.0°C
Resolution	AR : 0.001° / 0.01° / 0.1° by selection ISS : 0.001°Z / 0.01°Z / 0.1°Z by selection
Measurement Accuracy	AR : ±0.01° (-35.00 to +35.00°) Relative precision ±0.2% (-35.01 to -89.99°, +35.01 to +89.99°) ISS : ±0.03°Z (-101.00 to +101.00°Z) Relative precision ±0.2% (-130.00 to -101.01°Z, +101.01 to +130.00°Z) * Checked by reading a standard Quartz Plate at 10.0 to 30.0°C.
Temperature Compensation Range for ISS	18.0 to 30.0°C
Temperature Indication	Resolution : 0.1°C Accuracy : ±0.5°C
Ambient Temperature	Use the instrument where the temperature is between 10 to 40°C
Display Panel	LCD (320 × 240 dpi) with illuminating back light
Output	• Digital Printer DP-63 or DP-AD (Optional) • RS-232C input/output ports for connecting to a computer system
Observation Tube Included	200mm (10mL) × 1, 100mm (5mL) × 1
Measurement Wavelength	589nm (equivalent to the sodium-D line spectrum)
Light Source	white LED
Power Supply	AC100 to 240V, 50/60 Hz
Power Consumption	65VA
Dimensions & Weight	48.5×28.5×17.5cm, 14.4kg (Main Unit only)

Reference : AR = Angle of Rotation, SR = Specific Rotation, ISS = International Sugar Scale, Temp = Temperature, Conc = Concentration, RI = Refractive Index, ATC = Automatic Temperature Compensation

## An Affordable Polarimeter with Only the Essential Specs

Equipped with a history feature and a graphic display that allows you to instantly see whether measurement results are within standards. Capable of a minimum resolution of 0.001° for angle of rotation and up to 0.001°Z for International Sugar Scale. An ideal model for measuring angle of rotation in the pharmaceutical manufacturing, fragrance, cosmetics, industrial chemicals, and food industries, as well as for measuring International Sugar Scale degrees in the sugar refining industry.

### Compatible with the International Sugar Scale

Configured with automatic temperature compensation for a range within 18 to 30°C and conforms with International Commission for Uniform Methods of Sugar Analysis (ICUMSA) International Sugar Scale standards.



### Loaded with a multitude of convenient features

Data history of up to the last 30 measurement values, zero-setting, and calibration can be stored and checked. Other useful and convenient features for measurement include repeated (consecutive) measurement setting and average value display. Furthermore, it is equipped with a password protection feature in compliance with regulations such as ISO standards, for increased security.

### Compact design

Until recently, large-sized automatic polarimeters were the norm. Unlike conventional models that require a lot of space, the compact size of this instrument makes it possible to take measurements anywhere, without taking up space.

### AP-300 Special Packages

Options other than above mentioned 4 types are available. Contact your nearest ATAGO representative for details.

#### Type A Temperature Control

Recommended for Sugar Industry

Cat.No.5296

- AP-300 (including accessories)
- Inner Lid (for 200mm tube)
- Jacketed flow tube with funnel and temperature sensor for jacket (200mm-approximate volume 15mL)

\*Circulating Constant Temperature Bath 60-C5 (Cat.No.1923) sold separately

#### Type B No Temperature Control

Recommended for Sugar Industry

Cat.No.5297

- AP-300 (including accessories)
- Inner Lid (for 200mm tube)
- Unjacketed flow tube with funnel (200mm-approximate volume 15mL)

#### Type C Temperature Control

Recommended for Pharmaceutical Industry

Cat.No.5294

- AP-300 (including accessories)
- Jacketed flow tube (100mm)
- Inner Lid (for 100mm tube)
- Quartz Control Plate(8°, 17°, or 34°)
- Digital printer DP-AD • Printer paper for DP-AD
- Ribbon cassette for DP-AD
- Circulating Constant Temperature Bath 60-C5 (Cat.No.1923)

#### Type D No Temperature Control

Recommended for Pharmaceutical Industry

Cat.No.5295

- AP-300 (including accessories)
- Quartz Control Plate (8°, 17°, or 34°)
- Digital printer DP-AD
- Printer paper for DP-AD
- Ribbon cassette for DP-AD

### Measurement Method



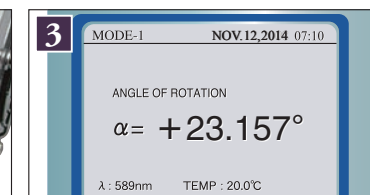
#### 1 Insert the sample

Place the sample into the observation tube and insert it into the sample chamber.



#### 2 Start

Close the lid and press START to begin measurement.



#### 3 Result display

Measurement values will be displayed.

Polarimeter

# POLAX-2L

Cat.No.5223



## Specifications

Measurement Scale	AR, ISS, Temp
Measurement Readings	AR, ISS, Temp
Measurement Range	AR : -179.95 to +180.00° ISS : -130.0 to +130.0°Z Temp : 5.0 to 40.0°C
Resolution	AR : 0.05° ISS : 0.1°Z Temp : 0.1°C
Measurement Accuracy	AR : ±0.10° ISS : ±0.3°Z Temp : ±0.5°C
Temperature Display Accuracy	±0.5°C
Ambient Temperature	5 to 40°C
Observation Tube Included	200mm (10mL) × 1, 100mm (5mL) × 1
Measurement Wavelength	589nm (equivalent to the sodium-D line spectrum)
Light Source	LED with interference filter (589nm)
Power Supply	AC100 to 240V, 50/60 Hz
Power Consumption	35VA
Dimensions & Weight	43×22×30cm, 10.3kg (Main Unit only)

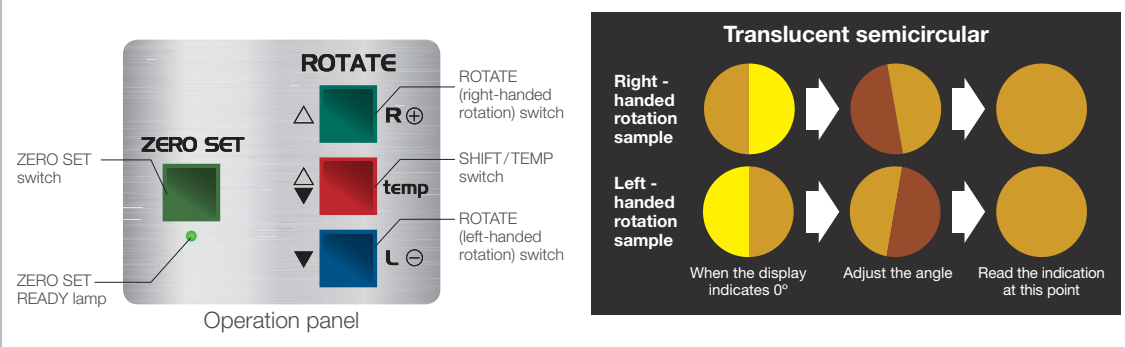
Reference : AR = Angle of Rotation, SR = Specific Rotation, ISS = International Sugar Scale, Temp = Temperature, Conc = Concentration, RI = Refractive Index, ATC = Automatic Temperature Compensation

## Fully Digital Display of Angle of Rotation and International Sugar Scale

A model with a newly equipped measurement temperature display and with all the advantages of conventional models left intact. Look through the eyepiece and match the brightness of the left and right translucent semicircular visual field with a switch. The measurement value will be digitally displayed on the front display panel. Best suited for educational uses such as studying polarized light, optical rotation, optically active substances, and optical activity at university or high school level physics and applied science courses.

### First-hand experience of the angle of rotation

By looking through the eyepiece while pressing the switch and manually adjusting the light's angle, you can experience and gain an understanding of optical rotation and angles, and learn about phenomena such as dextrorotation and levorotation.



### Equipped with a long-lasting LED light source

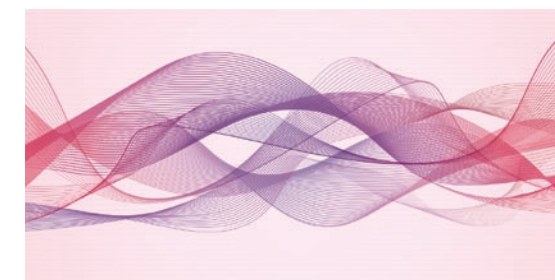
Outfitted with an LED light source that illuminates overwhelmingly fast and has a longer life-span compared to sodium lamps. Combined use with an interference filter ensures a wavelength of 589nm, equivalent to the sodium D-line.

### Smooth measurements with switch operations

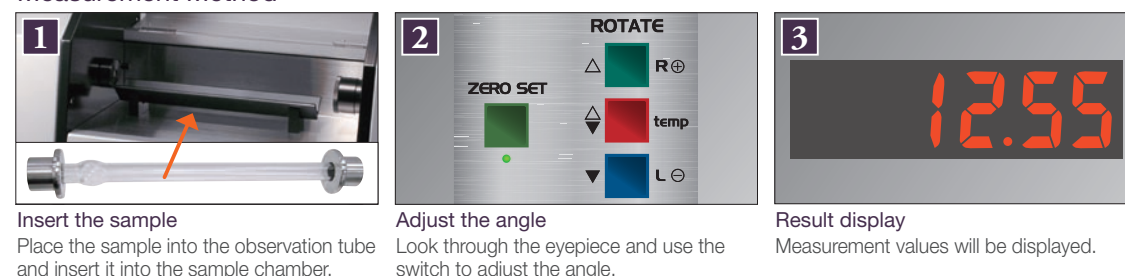
Just press the switches to rotate the analyzer. The rotation speed can be increased by pressing either the R (+) and L (-) switches together with the shift/temp switch.

### Easy to read, digitally displayed measurement values

The measurement method is easy; simply peer through the eyepiece and operate the switch. This allows you to rotate the analyzer, match the brightness of the left and right translucent semicircular visual field, and measure the angle of rotation. The results are fully digitally displayed. Additionally, the measurement temperature can be displayed by pressing the shift/temp switch.



### Measurement Method



**1** Insert the sample  
Place the sample into the observation tube and insert it into the sample chamber.

**2** Adjust the angle  
Look through the eyepiece and use the switch to adjust the angle.

**3** Result display  
Measurement values will be displayed.

Portable Refracto-Polarimeter

# RePo Series



## ISS RePo-1 Cat.No.5010

Standard model of the RePo Series. Toggle through Angle of Rotation, Brix, Purity, International Sugar Scale, Specific Rotation, and temperature displays simply by pressing a button.



## Portable Polarimeter Po-1 Cat.No.5050

The world's smallest high speed polarimeter. A compact and portable polarimeter. No observation tube necessary. Only small sample volume is required for measurements.

### Specifications

	RePo-1	RePo-2	RePo-3	RePo-4	RePo-5
Measurement Scale	ISS	Fructose % at HFCS	Invert ratio % at Invert sugar	Fructose % at Honey, Honey Moisture %	RI
Measurement Readings	User (ISS/Purity/SR/Conc) Purity/ISS: with ATC	User (Fructose %)	User (Invert ratio %)	User (Fructose %, Honey Moisture %)	User (RI/SR/Conc)
Measurement Range	ISS : -130 to +130 <sup>°Z</sup>	Fructose % : 0.0 to 99.9%	Invert ratio % : 0.0 to 99.9%	Fructose % : 0.0 to 99.9% Honey Moisture % : 13.0 to 30.0%	RI : 1.3306 to 1.5050
Display Range	ISS : -130 to +130 <sup>°Z</sup> *1 Purity : -120 to 120% *1 SR : -999 to +999 *1 Conc : -2.0 to 999% *1	Fructose % : -2.0 to 102%	Invert ratio % : -2.0 to 102%	Fructose % : -2.0 to 102% Honey Moisture % : 12.5 to 30.5%	RI : 1.3278 to 1.5093 SR : -999 to +999 *1 Conc : -2.0 to 999% *1
Resolution	ISS : 0.1 <sup>°Z</sup>	Fructose % : 0.1%	Invert ratio % : 0.1%	Fructose % : 0.1% Honey Moisture % : 0.1%	RI : 0.0001
Measurement Accuracy	ISS : ±3.0 <sup>°Z</sup> (at 20°C)	—	—	Honey Moisture % : ±0.2%	RI : ±0.0002 (at 20°C)
Repeatability	ISS : ±1.5 <sup>°Z</sup> (at 20°C)	—	—	Honey Moisture % : ±0.2% (at 20°C)	RI : ±0.0002 (at 20°C)
Temperature Compensation Range	ISS/Purity: 18 to 40°C	—	—	Honey Moisture % : 15 to 40°C	—

### Common Specifications

Measurement Scale	AR, Brix, Temp
Measurement Readings	AR, Brix, Temp, Brix (%) : with ATC
Measurement Range	AR : -5.00 to +5.00 <sup>°</sup> *2 Brix : 0.0 to 85.0% Temp : 15.0 to 40.0°C
Display Range	AR : -5.99 to +5.99 <sup>°</sup> Brix : -2.0 to 86.6% Temp : 14.0 to 41.0°C
Resolution	AR : 0.01 <sup>°</sup> Brix : 0.1% Temp : 0.1°C
Measurement Accuracy	AR : ±0.1 <sup>°</sup> (at 20°C) Brix : ±0.2% Temp : ±1.0°C
Repeatability	AR : ±0.05 <sup>°</sup> (at 20°C) Brix : ±0.1%

Measurement Time	12 seconds
Ambient Temperature	15 to 40°C
Storage Environment Temperature	0 to 65°C
Temperature Compensation Range	Brix : 15 to 40 <sup>°</sup>
Sample Volume	3mL
Measurement Wavelength	589nm (equivalent to the sodium-D line spectrum)
Light Source	LED
Power Supply	Size AAA alkaline battery × 4
International Protection Class	IP67
Dimensions & Weight	16×10.1×3.8cm, 325g (main unit only)

\*1 Measurements are round to 1 decimal place up to 99.9 and to a whole number above 100.  
\*2 These ranges are measured by the device's 20mm light path. These are convertible to below ranges: -25.00<sup>°</sup> to +25.00<sup>°</sup> with a 100mm observation tube, -50.00<sup>°</sup> to +50.00<sup>°</sup> with a 200mm observation tube

Reference : AR = Angle of Rotation, SR = Specific Rotation, ISS = International Sugar Scale, Temp = Temperature, Conc = Concentration, RI = Refractive Index, ATC = Automatic Temperature Compensation

## Simultaneous Measurement of Refractive Index and Angle of Rotation – Making the Invisible, Visible

The world's first hybrid device combining refractive index and angle of rotation: "Refracto-Polarimeter RePo." Simply place a mere 3mL of sample into the sample stage and press START to measure refractive index and angle of rotation. Measurement value display can also be switched with just one button.



## HFCS RePo-2 Cat.No.5012



HFCS (high-fructose corn syrup) is a liquid sweetener mixture of glucose and fructose. As it possesses a distinctive quality in which sweetness levels increase under low temperatures, it is used in soft drinks and frozen desserts. The RePo-2 displays the amount of fructose (%) contained in HFCS.



## Inverted Sugar RePo-3 Cat.No.5013



Inverted Sugar is a sweetener made by hydrolyzing (splitting) sucrose into glucose and fructose. In contrast to sucrose and glucose, which exhibit slight dextrorotation, fructose has strong levorotation. This instrument displays the amount of sucrose that was converted as an inverted ratio (%).



## Honey RePo-4 Cat.No.5014



In Europe, purity analysis through angle of rotation is designated per honey and food standards. This instrument measures the amount of fructose (%) among the sugars contained in the honey and honey moisture (%), which is useful when harvesting honey. Non-stick coating is applied to easily wipe off high viscous honey.

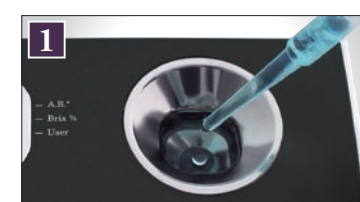


## RI RePo-5 Cat.No.5015



Displays refractive index. This model can display angle of rotation and refractive index, making it ideal for a wide range of samples and industries. Corrosion-resistant coating allows customers in pharmaceutical and fragrance industry to safely use it. (Quickly wipe off the sample after taking measurements as the instrument cannot be in contact with strong acidic or strong basic solvents for a long duration of time.)

### Measurement Method



**1** Insert the sample  
Fill the sample stage up to the fill line (approx. 3mL)



**2** Start  
Press START.



**3** Result display  
Measurement is displayed.

# RePo Series

## Measurement Result Display

Automatically calculates Purity, International Sugar Scale, Specific Rotation, and Concentration from Refractive Index and Angle of Rotation.



## Evaluation Indicator (RePo-1 only)

An indicator light alerts the user if a measurement value is within a range set by the user.

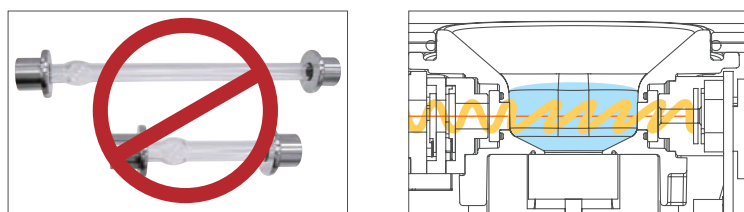
## Economical - Only a Small Amount of Sample Required

The sample amount is a mere 3mL. Simultaneously measures refractive index and angle of rotation. Compared to standard 100mm and 200mm observation tubes, much less volume of liquid (sample) is needed to complete measurements.



## Absolutely No Observation Tubes Necessary

The RePo requires absolutely no observation tubes whatsoever. No more hassling with sample prep, avoiding air bubbles, and washing out thin, narrow observation tubes.



## RePo-1 Special Packages

### RePo-1 Type A Recommended for sugar industry Cat.No.5020

- RePo-1 (Main unit)
- Beaker 100mL
- Syringe Filter Orange 45 (50pcs)
- Syringe 20mL (3pcs)
- Easy Filter (100pcs)



A package for the RePo-1 that includes syringes and single-use, disposable filters. By using a syringe and a disposable filter, it is possible to measure stabilized values of substances such as raw sugar and other materials. These accessories are also sold separately. For details, see "Optional Accessories" on pg. B21.

## 2 in 1

Refractive index and angle of rotation are measured simultaneously. Only 3mL of sample is required.








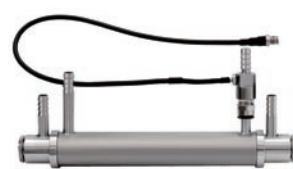

## The World's Smallest, Portable Device

A single device that can measure refractive index and angle of rotation. Compared to other polarimeters up until now, it is 1/20th the size, compact, and fits in the palm of your hand. Its portability means you can measure anywhere; you are no longer limited to a designated spot.

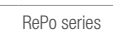


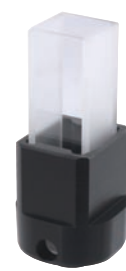



## Compatible With All Kinds of Samples

Samples with a high angle of rotation can be measured by diluting them.

# Optional Accessories

Part Name	Compatible models	Contents	Part No.		
<b>Quartz control plate</b> Used when confirming polarimeter values. 	SAC-i, AP-300, POLAX-2L	34° (100°Z)	RE-72045		
		17° (50°Z)	RE-72044		
		8° (25°Z)	RE-72043		
		-34° (-100°Z)	RE-72050		
		-17° (-50°Z)	RE-72049		
		-8° (-25°Z)	RE-72048		
<b>Unjacketed small volume observation tube</b> 	SAC-i, AP-300 POLAX-2L	10mm / 1mL	RE-72042		
		100mmOT-100 (M) / 1mL	RE-6723		
<b>Observation tube</b> 	SAC-i	50mmOT-50 (I) / 2.5mL	RE-72080		
		100mmOT-100 (I) / 5mL	RE-72078		
		200mmOT-200 (I) / 10mL	RE-72079		
		AP-300	50mmOT-50 (A) / 2.5mL	RE-72056	
		100mmOT-100 (A) / 5mL	RE-72054		
		200mmOT-200 (A) / 10mL	RE-72055		
	POLAX-2L	50mmOT-50 (P) / 2.5mL	RE-6722		
		100mmOT-100 (P) / 5mL	RE-6720		
		200mmOT-200 (P) / 10mL	RE-6721		
		<b>Jacketed flow tube with funnel</b> Sample can be inserted through the funnel while attached to the unit. Constant temperature water bath connectivity capability. 	SAC-i, AP-300	100mm	RE-72118
				200mm	RE-72119
				<b>Unjacketed flow tube with funnel</b> Sample can be inserted through the funnel while attached to the unit. 	SAC-i, AP-300
200mm	RE-72121				
<b>Jacketed flow tube</b> Sample can be inserted using a syringe or the like while attached to the unit. Constant temperature water bath connectivity capability. 	SAC-i, AP-300	50mm	RE-72115		
		100mm	RE-72116		
		200mm	RE-72117		
<b>Unjacketed flow tube (Glass)</b> Sample can be inserted using a syringe or the like while attached to the unit. 	SAC-i, AP-300, POLAX-2L	50mm / 4.5mL	RE-72051		
		100mm / 9mL	RE-72052		

**Discount Set**  
 Purchase a quartz plate and a polarimeter as a set and receive a discount. For details, please contact ATAGO.

Part Name	Compatible models	Contents	Part No.
<b>MAGIC™ for RePo</b> Anti-volatile sample cover. 	RePo series		RE-79000
<b>Standard liquid RePo-series</b> Standard liquid for the RePo Series, used for checking Brix and angle of rotation. The warranty period of an unopened bottle is 6 weeks from date of manufacture. 	RePo series	7mL	RE-99110
<b>Beaker 100mL</b> Beaker included in "Package A" of the RePo Series. 	RePo series		RE-79423
<b>Syringe 20mL (3pcs)</b> Syringe included in "Package A" of the RePo Series. 	RePo series		RE-79421
<b>Syringe Filter Orange 45 (100pcs)</b> Disposable filter used by placing on the syringe (RE-74921). 	RePo series		RE-79420
<b>RePo Small Volume Adapter</b> Angle of rotation can be measure with small amount of sample volume. Minimum liquid volume 0.6mL. * Can only measure optical activity. 	RePo series		RE-72093
<b>RePo Reduced Optical Path Adapter</b> By shortening the optical path length, colored or cloudy sample can be effectively measured. Minimum liquid volume 5mm: 0.3mL 10mm: 0.54mL. * Can only measure optical activity. 	RePo-5	Reduced Optical Path Adapter 5mm	RE-72094
		Reduced Optical Path Adapter 5mm (Adapter only)	RE-72095
		Reduced Optical Path Adapter 5mm (Glass Cell only)	RE-72096
		Reduced Optical Path Adapter 10mm	RE-72097
		Reduced Optical Path Adapter 10mm (Adapter only)	RE-72098
		Reduced Optical Path Adapter 10mm (Glass Cell only)	RE-72099
<b>Circulating constant temperature bath 60-C5</b> Circulating constant temperature water bath used by connecting to a jacketed flow tube with funnel or jacketed flow tube. 	SAC-i, AP-300	1.0L	Cat.No.1923
<b>Digital printer DP-63</b> A printer compatible with thermal paper. 	SAC-i, AP-300		Cat.No.3118
<b>Digital printer DP-AD</b> A printer compatible with plain paper. 	SAC-i, AP-300		Cat.No.3123



## Measurement Tips

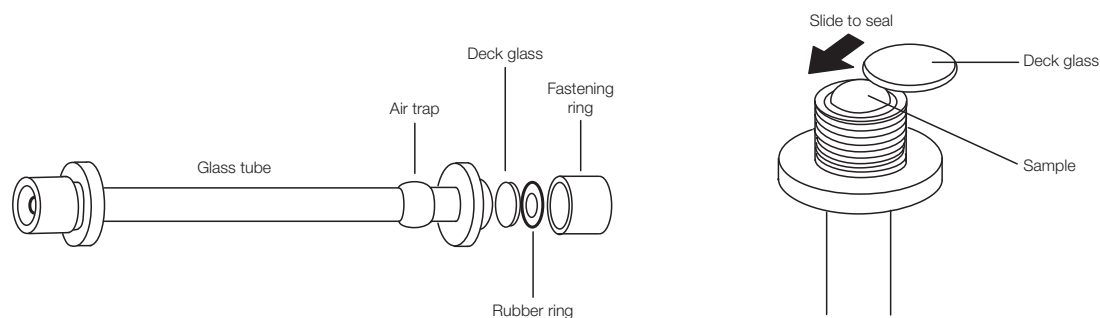


### Arrangements

- Avoid differences in temperature by placing the instrument, observation tubes, samples, and other materials in the same location and letting them sit for a while.

### Sample prep and observation tubes

- For highly transparent samples, use a long observation tube for better measurement accuracy.
- For samples with low transparency (opaque), use a short observation tube for improved measurement. A long observation tube will make it difficult for light to pass through.
- For samples that are too opaque to measure as-is, dilute the sample with water to increase transparency in order to measure the sample.
- The 882nm wavelength can easily pass through low transparency samples, like raw sugar. ATAGO recommends the SAC-i 589/882 for raw sugar.
- As depicted in the figure below, observation tubes are composed of the tube itself, deck glass, rubber ring, and a fastening ring. When filling the observation tube with sample, the final step involves using the surface tension of the liquid to make it swell out at the top. Slide the deck glass on and place it on top. Take the utmost care to avoid air bubbles. Put the rubber ring and fastening ring back on.



\* Make sure use a clean and dry observation tube always.

- Over-tightening the fastening ring will cause warping and bending, which will affect measurement values. Tighten the fastening ring just enough to avoid leaks. Do not tighten it any further.
- In the event that air bubbles are present, ATAGO's observation tubes have an "air trap." Provided that the air bubbles are small enough, the air trap can be adjusted so that the air bubbles accumulate in that section when the observation tube is inserted into the instrument, allowing for measurements to be taken as-is.

# Polarimeter FAQ

**Q. What is the cause of unstable values? Please tell me how to resolve this issue as well.**

**A.** The most prominent cause of unstable values is liquid sample fluctuation.

Troubleshooting steps:

- ① If placing the observation tube in the sample chamber, let it sit for about 5 to 15 min. until the liquid stabilizes.
- ② Even slight temperature increases in the sample chamber will lead to changes in the refractive index of the liquid and fluctuation. Except for during measurement, keep the sample chamber cover open to avoid temperature increases in the sample chamber.
- ③ Due to condensation, the deck glass of the observation tube may become cloudy, or air bubbles may be present. If this occurs, either refill the sample tube or separate the air bubbles in the air trap.

Aside from sample fluctuation, other causes may be that the angle of rotation value is quite small, resulting in significant relative errors.

**Q. What should I do if I want to measure a sample with an angle of rotation that exceeds the measurement range?**

**A.** Provided that a sample is between  $-90^\circ$  to  $+90^\circ$ , polarimeters can accommodate almost any sample, as far as measurement range. However, although uncommon, there are some samples that are  $+120^\circ$  or  $-110^\circ$ . Nonetheless, as an example, there are cases, where a sample which is assumed to be  $+120^\circ$ , actually measures at  $-60^\circ$ . For further details regarding this kind of situation, please see the following "Q&A."

**Q. When I measured a sample with an angle of rotation that I expected to be  $-130^\circ$  with a 200mm observation tube, the measurement value was  $+50^\circ$ . Why did this happen?**

**A.** The angle of rotation, as evinced by the term, is an angle. Using a clock to illustrate, 12 o'clock corresponds to  $0^\circ$ , 3 o'clock corresponds to  $90^\circ$ , 6 o'clock corresponds to  $\pm 180^\circ$ , and 9 o'clock corresponds to  $-90^\circ$ . For example, if the angle of rotation is  $-130^\circ$ , it may appear as a measurement value of  $50^\circ$ , which is symmetrical to  $180^\circ$ . In such cases, either use an observation tube that's half the length (100mm) for measurement, or dilute the sample's concentration by 2, then measure. This will result in  $-130^\circ$  measuring as  $-65^\circ$ . If the value is  $+50^\circ$ , then it will measure as  $+25^\circ$ . Given the above, it is possible to determine which of the values,  $-130^\circ$  and  $+50^\circ$ , is correct.

**Q. I'm measuring raw sugar, but because of the coloration, I can't measure it properly. What sort of preparations do I need to do before measuring?**

**A.** The RePo-1's "Package A" is available to meet these kinds of demands and dispel any doubts concerning measurement.

By using the syringe and disposable filter, it is possible to easily measure raw sugar. For details, please see pg. B19.

**Q. What level of accuracy is required for a constant temperature water bath when adjusting the temperature?**

**A.** In order to retain the angle of rotation accuracy of  $\pm 0.01^\circ$  for a  $34^\circ$  quartz plate (standard polarizing plate) and a sucrose solution of  $34.626^\circ$ , temperature must be regulated within  $\pm 0.6^\circ\text{C}$ . Taking other margins of error aside from temperature into account, it is

best to use a constant temperature water bath with an accuracy of at least  $\pm 0.3^\circ\text{C}$ .

**Q. Does this conform with the Japanese Pharmacopoeia?**

**A.** The Japanese Pharmacopoeia states that, "The angle of rotation  $\alpha$ , shall be defined as a value (angle of rotation) measured at a certain temperature degree ( $t^\circ$ ), using a specified monochromatic light  $\lambda$  (written as "wavelength" or using its common term). This measurement shall commonly be performed at a temperature of  $20^\circ\text{C}$ , with an observation tube of 100mm, and with the D-line of the sodium spectrum." "Sodium spectrum" indicates the D-line. Basically, it means to take measurements at the 589nm D-line. It does not mean that a sodium lamp must be used. ATAGO's polarimeters use components such as filters to measure at a wavelength equivalent to the sodium spectrum's D-line.

\* Confirmed with the Ministry of Health, Labour and Welfare Pharmaceutical Inspection Regulation Division.

$[\alpha]_D^{20}$  Specific rotation measured at  $20^\circ\text{C}$  at D line ...  $[\alpha]_D^{20}$

**Q. Why does the temperature of the sample chamber increase?**

**A.** Unfortunately, this is caused by normal, internal construction heat build-up. Except for during measurement, keep the sample chamber cover open to avoid temperature increases in the sample chamber.

**Q. What should I do about sample leakage?**

**A.** Do not allow liquid to contact the O-ring (depending on the type of chemical, it may cause the O-ring to melt, which might result in leakage). An old, deteriorated O-ring may also be the cause of leakage. If this is the case, please purchase a new O-ring.

**Q. Tell me how to clean the inside of the observation tube after using a jacketed flow tube with a funnel.**

**A.** After washing with water (or pre-rinsing with the solution being measured), allow the observation tube to air-dry naturally.

**Q. I would like to use hydrochloric acid as a solvent; do you have any products that are compatible with this application?**

**A.** Normal observation tubes (the sections in direct contact with the liquid) are made of glass materials, so there generally isn't an issue with chemical resistance. However, if sample leaks out of the O-ring, it could potentially come into contact with metallic components, which is something to be aware of. There are various kinds of optional accessories, such as jacketed flow tubes with funnels, that are compatible or incompatible with certain applications. There are also flow tubes made entirely of glass. For details, please contact ATAGO.

**Q. Do you offer validation services?**

**A.** We can perform IQ (Installation Qualification) and OQ (Operational Qualification) services. However, please note that the inspection will be done with an accuracy that takes the environmental conditions into account. For details, please contact ATAGO.

\* The minus symbol signifies a levorotatory substance.