

# FEATURE SERVICE

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## **Safely tucked away: A Cyclodextrin Wrapper Protects Functional Ingredients for Foods and Beverages**

**Molecules with special talents: cyclodextrins resemble donuts that are able to accommodate specific molecules and then selectively release them. This principle is finding application in particular for health-promoting ingredients. Cyclodextrins are able to hide the sometimes bitter taste of functional ingredients, protect these sensitive substances and ensure that they are better absorbed by the body.**

**Vitamins keep us young and healthy**

Vitamins keep living cells young: Linus Pauling, winner of the 1954 Nobel Prize in Chemistry, was so convinced of their efficacy that he consumed almost 18 grams of pure vitamin C a day. It's debatable whether that's why he lived to be over 90. One thing is certain, though: the body cannot function long without vitamins, minerals and trace elements. And scientists are discovering new health-promoting ingredients all the time that make the body resistant to environmental stress, prevent certain diseases or even slow the aging process.

**Green tea has an antibacterial and anti-inflammatory effect ...**

Green tea, for example, is reputed to confer health benefits. Its tannins contain "catechins," compounds with antibacterial properties that are capable of neutralizing free-radicals. As well as being anti-inflammatory, catechins are thought to play a role in cancer prevention. "But it's the catechins that make green tea taste very bitter," says Heiko Zipp, head of the Nutrition business team at WACKER BIOSOLUTIONS, the company's life sciences and biotech division.

**... but has a bitter after-taste**

**Taste is important –  
even for functional  
foods**

Food companies are thus faced with a dilemma. On the one hand, they want to provide their products with an additional health-promoting benefit, which is why they fortify soft drinks, for example, with green tea extract. But, on the other hand, by adding this functionality, they are incorporating the bitter aftertaste. True, the product does contain the desired health promoter, “but of course no consumer wants a thirst quencher that has a bitter taste,” explains Zipp. “Even in functional foods the consumer is concerned about taste first and foremost.”

**More sugar or flavor is  
not wanted**

One option is to mask the bitter catechin taste, for example, with more sugar. However, more sugar means more calories, which is not always acceptable. Another solution is to use additional flavors, but these weigh on costs and can impair the flavor profile.

**The solution:  
a cyclodextrin wrapper**

WACKER’s development team has devised another option: a wrapper made of cyclodextrins. These ring-shaped molecules, which are produced enzymatically from starch, are able to incorporate other molecules in their inner cavity. The bitter substance contained in green tea is bound in the cyclodextrin, so its taste is no longer perceived by the consumer.

**The cyclodextrins incor-  
porate the bitter sub-  
stances ...**

"Our cyclodextrins offer an attractive way of masking health-promoting food ingredients that would otherwise taste unpleasant," says Zipp. The primary goal of his business team is to develop ingredients and solutions for the food industry and its suppliers. "Cyclodextrins can help us to selectively improve the bitter components in beverages, for example," adds Dr. Ralf Mezger, a brewery and beverage technology engineer who in early 2011 became the director of the newly created laboratory for dietary

**... and thus mask the undesired aftertaste**

**The food labs process products tailored to customers' needs ...**

**... and, among others, develop dietary supplement solutions**

**Coenzyme Q10 plays a key role in the body ...**

supplements at WACKER's largest site in Burghausen.

"We're concentrating on developing new product solutions for the beverage and dairy industries," says Mezger. At the top of the Food Laboratory's agenda are analytical test methods, the optimization of taste and the stability of sensitive ingredients. "We want to devise custom solutions with clients so as to enable and optimize the use of functional substances in their products."

Besides the newly established test laboratory in Burghausen, WACKER has a food laboratory in Adrian, Michigan which has been in operation since 2006. The developers' focus is mainly on dietary supplements. These include all kinds of vitamin capsules and powder blends containing essential trace elements and health-promoting substances. Often, the challenge posed by these products lies in ensuring that the active ingredients are absorbed by the body. The substances in the product must therefore be bioavailable, as only then will they prove efficacious in the body. Whereas hydrophobic (i.e. "water-avoiding") substances are poorly absorbed into the bloodstream, hydrophilic (i.e. "water-loving") compounds are absorbed much more readily. "This is where cyclodextrins come in, as they can give a substantial boost to the bioavailability of hydrophobic substances," says Dr. Helmut Reuscher, director of sales in the Americas and head of WACKER's Dietary Supplements Laboratory in Adrian, Michigan.

One functional ingredient that is often employed in dietary supplements is coenzyme Q10. This vitamin-like molecule is present in every human cell, where it plays a central role of ensuring that the food we eat is converted efficiently into energy. The down side: "Coenzyme Q10 has very poor water solubility and thus has

**... but has very poor solubility in water**

very little bioavailability,” says Dr. Reuscher. “As a dietary supplement, though, it is very interesting because its concentration in a person’s body decreases with age. Eighty-year-olds have only half as much coenzyme Q10 as twenty-year-olds.”

**Cyclodextrins are able to increase bioavailability**

Dietary supplements are a proven way of keeping the stores of coenzyme Q10 well stocked – particularly in people who are engaged in heavy physical work, are under stress or are elderly. Yet, it cannot be simply stirred into water and then drunk. Coenzyme Q10 would float on the surface like fatty cocoa powder and form insoluble lumps. Furthermore, only a fraction of the added coenzyme Q10 would be absorbed. “We can use cyclodextrins to increase its solubility and thus boost its bioavailability,” says Reuscher, a biochemist. “The ring-shaped cyclodextrins have a hydrophobic ‘pocket’ and a hydrophilic shell, and look somewhat like a donut.” Coenzyme Q10 tucks itself away inside this donut, creating a complex with the cyclodextrin.

**They take up the molecule ...**

After being stirred into liquid, the coenzyme within the cyclodextrin forms a molecular dispersion which the body can absorb much more readily. “Release of coenzyme Q10 within the body is a chemical equilibrium process in which the molecules gradually come ‘out of their shell’,” says Reuscher. In vitro and in vivo studies have shown that coenzyme Q10 uptake can be substantially improved if it is complexed with a cyclodextrin-coenzyme Q10 complex.

**... and then selectively release the active ingredient**

The complexation with cyclodextrins yields a free-flowing powder, containing at least 20 weight-percent of the functional active ingredient, which has high bioavailability. One of WACKER’s customers is US-based Tishcon Corporation. It is already success-

**Powdered coenzyme Q10 is obtained**

fully using this innovative packaging for coenzyme Q10 in its own line of dietary supplements and in products for private-label companies. For the first time, the complexation with cyclodextrins has provided the opportunity to offer powder-based coenzyme Q10 products which have the same high bioavailability as liquid formulations.

**Alpha-lipoic acid is an efficient free-radical scavenger ...**

Another useful property of cyclodextrins is their protective action. Cyclodextrins shield numerous functional compounds against various external influences (low pH, oxygen, and light) that could compromise their effectiveness. For example, they are highly adept at stabilizing alpha-lipoic acid, which is also used in dietary supplements and in sports nutrition. This substance acts as an efficient free-radical scavenger, neutralizing aggressive oxygen molecules which are formed by cell metabolism and which can damage the body.

**... but is very sensitive and difficult to handle**

What's more, alpha-lipoic acid can regenerate other, spent antioxidants (vitamin C and vitamin E; coenzyme Q10), which is of interest for competitive athletes. In addition to protein drinks and energy bars, there are special powder mixtures available which are designed to replenish the depleted reserves of vitamins, minerals and antioxidants – including alpha-lipoic acid. This compound is not easily incorporated into powder products as it is very sensitive, especially to heat and the presence of certain minerals. "Even in the dry state, it can polymerize, i.e., form long, chain-like structures," explains Reuscher. "This chemical reaction causes the alpha-lipoic acid to lose its desired effect."

**Cyclodextrins protect**

Again, cyclodextrins can act as a practical protective wrapper: embedded in the cyclodextrin, the sensitive molecule is safely

**sensitive molecules ...** tucked away inside the athlete's special powdery dietary food. As soon as the cyclodextrin complex comes into contact with water, the alpha-lipoic acid emerges from its protective coat and is absorbed directly by the body – the free-radical scavenger enters the bloodstream unscathed. This protective solution was specifically developed by WACKER on behalf of AlzChem Trostberg GmbH, a German specialty chemicals company whose portfolio includes products for the food and sports nutrition field. The specialized cyclodextrin complex maximizes the product's efficiency by ensuring that as much of the free-radical scavenger as possible remains effective in the powdered end product.

**... and lend themselves to use in sports nutrition**

**Customized research and development**

All of these examples illustrate the new approach adopted by WACKER BIOSOLUTIONS, especially regarding the Nutrition and dietary supplements business team's strategy, namely, the development and delivery of complete solutions tailored specifically to customers and their needs. "Many small and medium-sized suppliers of the food industry do not have their own R&D departments," says Zipp. "This is our point of entry, where we use our expertise, our experience and our services to work together with customers on tailor-made solutions." For the future, the WACKER developers are targeting primarily three main effect platforms: masking of unpleasant tastes of ingredients, stabilization of sensitive ingredients and improving the bioavailability of functional ingredients.

**Three effect platforms for functional foods**

**WACKER exploits synergies between chemistry and biotechnology ...**

For the food specialists at WACKER, cyclodextrins are a perfect example of how biotech know-how and chemical expertise successfully interact. "We want to redouble our efforts at exploiting synergies between these two areas of expertise and to de-

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**... in order to develop tailor-made solutions for the food industry**

velop innovative biotech products with high added value," says Zipp, summarizing the potential of this field. "Alongside WACKER BIOSOLUTIONS' strong biotech and chemical expertise, another key aspect of our strategy is to develop and provide customized solutions." The use of cyclodextrins in dietary supplements or as food additives is one of many innovative ways in which the WACKER Group will be seeking to assist the food industry in the future.

**Background information on cyclodextrins**

Cyclodextrins are molecules composed of several glucose units linked up to form a ring. Depending on the number of glucose units, and accordingly, also the ring size, a distinction is made between  $\alpha$ -,  $\beta$ - and  $\gamma$ -cyclodextrin. Cyclodextrins are natural degradation products of starch, and cyclodextrins themselves are also completely biodegradable.

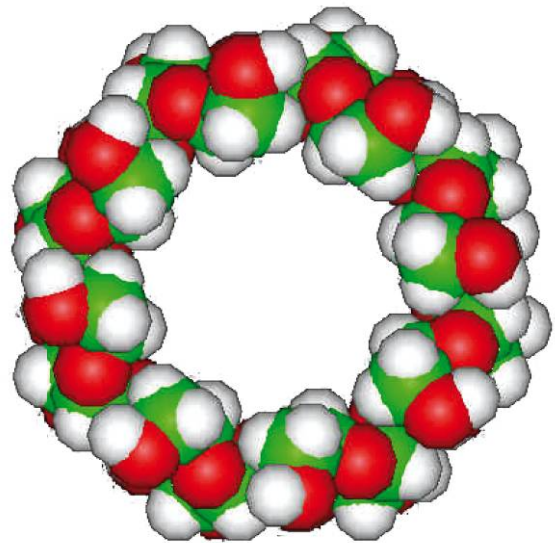
The glucose units are configured in the cyclodextrin molecules in such a way that a lipophilic, i.e., "fat-loving," cavity results. This cavity is able to accommodate another lipophilic molecule as a "guest" as long as its size and shape are compatible. The cohesion between the two molecules is relatively weak (van der Waals forces), so that under suitable conditions the guest molecule may once again be released. The weak van der Waals forces do not chemically alter either partner of such an inclusion compound.

Due to their ability to reversibly incorporate other substances, cyclodextrins are already being used in many products and industrial sectors besides the food industry, for example in home and personal care products, in pharmaceutical and cosmetic preparations, and in the textile and construction industries.

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Cyclodextrin model: The ring-shaped molecules are able to incorporate specific substances such as vitamins, which are released by moisture and discharged to the surroundings in a controlled manner (Graphic: Wacker Chemie AG).



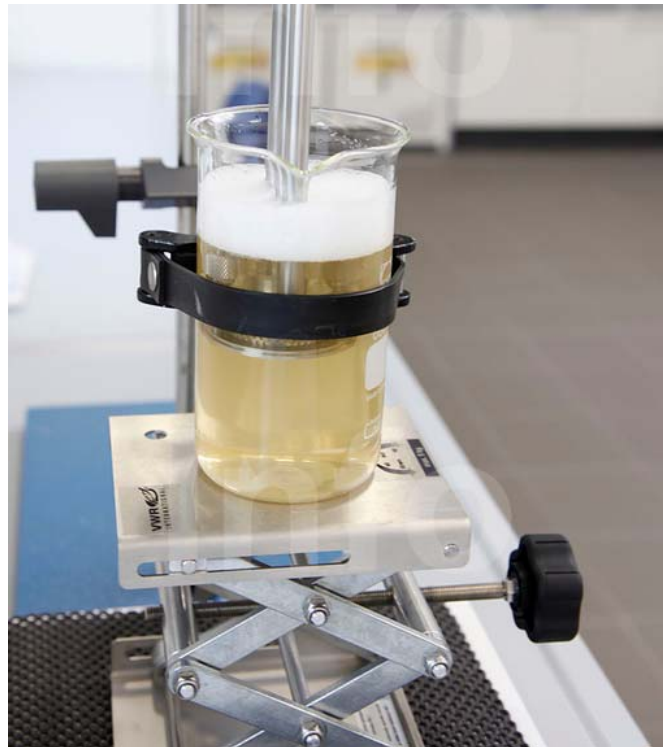
Testing samples in the Nutrition and dietary supplements laboratory in Burghausen: the molecular inclusion in cyclodextrin binds the bitter substances, thus eliminating the perceived taste (Photo: Wacker Chemie AG).



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Various cyclodextrin inclusion compounds undergo rigorous testing in the Food Laboratory in Burghausen. The ring-shaped molecules are used to improve the solubility or the stability of substances, to reduce the volatility of materials or to mask unpleasant odors (Photo: Wacker Chemie AG).



*Note: These images may be downloaded from the Internet at:  
<http://www.wacker.com/pressreleases>*

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**The company in brief:**

WACKER is a globally-active chemical company with some 16,300 employees and annual sales of around €4.75 billion (2010). WACKER has 26 production sites, 20 technical competence centers and 50 sales offices.

**WACKER SILICONES**

Silicone fluids, emulsions, rubber and resins; silanes; pyrogenic silicas; thermoplastic silicone elastomers

**WACKER POLYMERS**

Polyvinyl acetate and vinyl acetate copolymers in the form of dispersible polymer powders, dispersions, solid resins and solutions used as binders for construction chemicals, paints, adhesives, coatings, textiles and nonwovens, as well as in polymeric materials based on renewable resources

**WACKER BIOSOLUTIONS**

Biotech products, such as cyclodextrins, cysteine and biologics, and also fine chemicals and polyvinyl acetate solid resins

**WACKER POLYSILICON**

Polysilicon for the semiconductor and photovoltaics industries

**Siltronic**

Hyperpure silicon wafers and monocrystals for semiconductor components