Polysaccharides (Sugars, Gums) Used in Cosmetics

Polysaccharides form another important group of polymers. As the name suggests, polysaccharides are composed of multiple saccharides (sugars) forming a large, branched or unbranched chain. The vast majority of polysaccharides used in cosmetics are natural or semi-natural. Based on their unique multifunctionality they play a very important role in cosmetic formulation technology. For example, polysaccharides act as thickeners, suspending agents, hair conditioners, moisturizers, emulsifiers, emollients, and even wound-healing agents. However, this multifunctionality of polysaccharides may sometimes make formulation difficult as, for example, a polysaccharide that conditions may do so at the expense of its thickening ability.

Traditionally, polysaccharides are classified based on their electrochemical charges (see table below).

Classification of Polysaccharides

Anionic Polysaccharides

Natural: alginic acid, pectin, xanthan gum, hyaluronic acid, chondroitin sulfate, gum arabic, gum karaya, gum tragacanth

Semi-Natural: carboxymethyl-chitin, cellulose gum

Cationic Polysaccharides

Natural: chitosan

Semi-Natural: cationic guar gum, cationic hydroxyethylcellulose (HEC)

Nonionic Polysaccharides

Natural: starch, dextrins, guar gum

Semi-Natural: cellulose ethers (e.g. hydroxy-ethylcellulose, methylcellulose, nitrocellulose)

Amphoteric Polysaccharides

Semi-Natural: carboxymethylchitosan, N-hydroxy-dicarboxyethyl-chitosan, modified potato starch

Hydrophobic Polysaccharides

Semi-Natural: cetyl hydroxyethylcellulose, poly-quaternium 24

Anionic Polysaccharides (negative charge)

The cosmetically interesting anionic polysaccharides are predominantly comprised of naturally occurring materials. A major compound in this group is xanthan gum. It occurs on the cell walls of bacteria and is isolated by bacterial fermentation. In water xanthan polymerizes to form viscous liquids with cristals with the unique ability to form emulsifier-free suspensions. Although the viscosity of xanthan solutions is influenced by cationic salts, xanthan does not require salts to build a viscous solution since it forms a rigid backbone that is remarkable stable at increasing temperatures. Xanthan also helps to reduce the quantity of primary emulsifiers. Due to these properties xanthan gum is widely used as thickening agent in the cosmetic industry.

Hyaluronic acid and chondroitin sulfate are two other major components among anionic polysaccharides. Both of them are primarily used as moisturizer based on their great water-binding capacity (see also Newsletter No. 17, November 2005).

Gum arabic, gum karaya, and gum tragacanthis are some of the oldest and commerically well-established anionic polysaccharides. They are isolated from the sap of specific trees and bushes. Gum arabic consists of a chain of galactose sugars. Because of its low molecular weight, gum arabic is mainly used in applications where high levels of sugar solids are desired without significant viscosity buildup. The maximum viscosity effect occurs at ph 6, but disappears quickly at higher or lower ph values. Gum arabic dissolves in water and can bind fat particles. It is thus classified an emulsifier. It is of note that anionic polysaccharides are only compatible with anionic, nonionic or amphoteric surfactants (e.g. sulfosuccinate, polyglucose or cocamidopropyl betaine), but not cationic surfactants like quaternium-containing agents (used as conditioners). For example, the addition of quaternium 87 to a solution containing xanthan gum will make the xanthan to floculate and settle out of solution.

Cationic Polysaccharides (positive charge)

The cationic polysaccharides of cosmetic interest consist mainly of synthetically altered polyglycans. They have the unique advantage to bind tightly to proteins (negatively charged) of the human skin and hair. Cationic polysaccharides have therefore been found to be very useful as film-forming and damage control agents in conditioning hair and skin preparations. Cationic polysaccharides are also widely used in hair fixative formulations.

The two most used cationic polysaccharides are cationic hydroxyethylcellulose (HEC) and cationic guar gum. There are two major cationic HEC available: HEC 27 (polyquaternium 10) and HEC 28 (polyquaternium 4). Both are widely used as thickener and hair repairing agents for bleached, i.e. heavily damage hair. The thickening effect depends largely on the molecular weight of the cationic HEC. The higher the molecular weight, the more intense is the thickening effect. Cationic guar gum has very similar properties to cationic HEC as it thickens and repairs damaged hair cuticles. One of guar gum's distinctive features, however, is the lubricious, creamy feel it lends to the formulations.

Nonionic Polysaccharides (no charge)

Nonionic polysaccharides are not charged and thus less affected by negatively or positively charged compounds as surfactants. Starch as one of the most used and least expensive natural nonionic polysaccharides is mainly used as thickener. By the addition of inorganic thickeners (e.g. bentonite) the thickening effect of starch can be increased significantly. A disadvantage of starch is that the solutions become hazy. Guar gum, another non-ionic polysaccharide, has found broader appeal as a natural thickener. Guar is isolated from the seeds of various bean-growing plants and consists of two sugars, mannose and galactose. Together with metal ions (e.g. borate) guar gum is able to create thick gels if the pH does not become acidic. Semi-natural nonionic polysaccharides are mainly ethers of cellulose or guar-based materials like hydroxy-ethylcellulose, methylcellulose, nitrocellulose, or hydroxypropylguar. They are used either as thickeners, film-formers or nail polishers.

Amphoteric Polysaccharides (2 charges)

Amphoteric polysaccharides carry both positive and negative charges on the same molecule. There are very few natural amphoteric polysaccharides barely used in cosmetics. Similarly, the semi-natural amphoteric polysaccharides, as carboxymethyl-chitosan or hydroxydicarboxyethylchitosan are relatively unknown and underutilized in cosmetics. They are challanging to formulate as they can change their solubility and show complex behaviours in the presence of surfactants or salts.

Hydrophobic Polysaccharides

Hydrophobically modified (HM) polysaccharides are of increasing interest in cosmetics. By attaching lipophilic groups to the polysaccharides they become less water-loving and show new, often unusual thickening characteristics. For example, the thickening effect of HM-HEC is no longer dependent on water but on the concentration of surfactant which is a great advantage to formulate fixative gels or hair sprays.

Sources: Goddard ED, Gruber JV. Principles of polymer science and technology in cosmetics and personal care. M. Dekker, New York, P325-389

T. Bombeli, MD BBA