Supramolecular Chemistry-I

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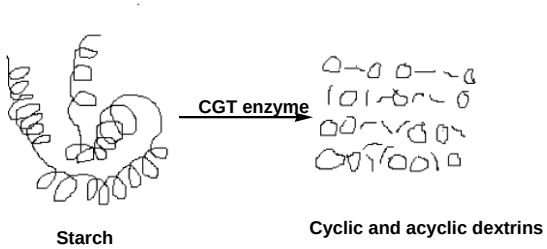
Week - 03

Lecture - 14

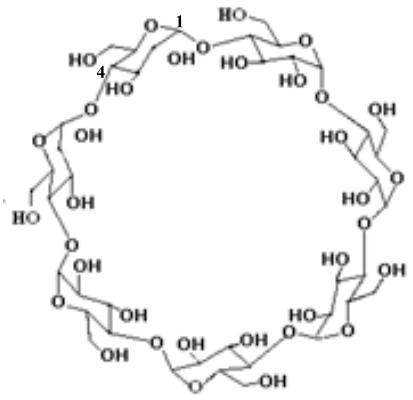
Good morning. So, today I will discuss another very important cyclic compound called cyclodextrin. There are specifically three cyclodextrins that are very important: alpha, beta and gamma cyclodextrins. Now, photosynthesis by plants produce glucose polymers. So, plants produce glucose polymers from plants we can get glucose polymers. What are these glucose polymers? This glucose polymers are called cellulose and starch.

Now, cellulose is an insoluble material that is used in resistant and structure forming component in the cell like in a tree the outer part is made of cellulose. Starch is a convertible energy source. We are interested in this starch. Now starch has two polymers, one is made up of several thousand D-glucopyranoside units linked by α-1,4-glycosidic linkages while (ii) the other possesses both α-1,4- and α-1,6-linkages. Now, these polymers can be degraded by various means like acid treatment, by heat, by ionizing radiation in presence of water to form a mixture of degradation products called dextrins.

These dextrins are very important compounds, they are produced in large quantities for industrial applications. They are used in cosmetics, used as food items and so on. Big industries are there. However, when starch is degraded enzymatically using the enzyme called cyclic glycotransferase (CGT enzyme), without using water. It can be degraded where the primary products are cyclic, primary products are cyclic 1,4-linked compounds, called cyclodextrins. Let us show it this way:

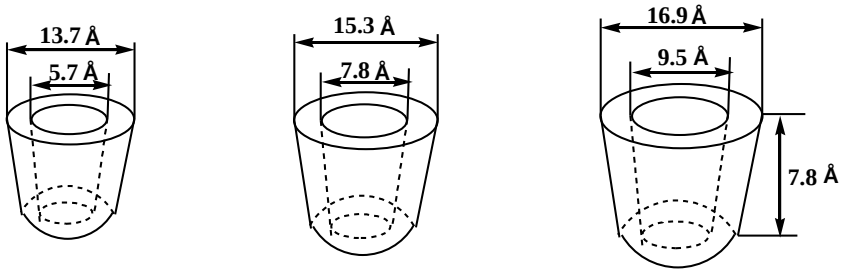


So we get a mixture of cyclic and linear products called dextrins. The cyclic compounds are called cyclodextrins. So, let me draw a picture of cyclodextrin. It will take a while, nevertheless I will attempt. There are three important cyclodextrins named- alpha, beta and gamma cyclodextrins for six-, seven- and 8-membered cyclic compounds respectively. So, the drawing below is that of beta-cyclodextrin, in short β-CD.



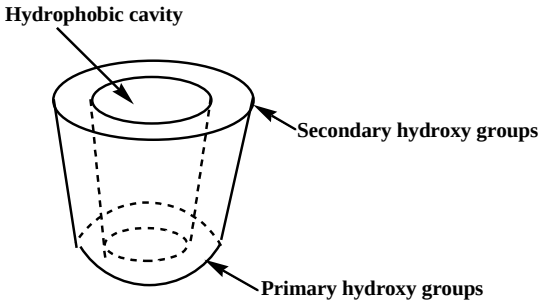
β-CD

You have to understand 1,4-linkages. I have indicated for one unit, but these are all one four linked. Okay. And they are cyclic. So, that is why they are known as cyclodextrin. This particular one when it is seven we call it beta cyclodextrin. How this molecule look? This molecule is not planar. Okay. But it has a three-dimensional structure. Let me draw all these.



α-CD β-CD γ-CD

So, these three cyclodextrins look somewhat conical shape and different measurements of these molecules are also indicated. The middle portion has some width due to the glucose units present there. They are open-ended on both sides. This side with smaller circular radius has the primary hydroxyl group that is CH_2OH groups. The side with larger radius has secondary hydroxyl (CHOH) groups. All OH groups are outside the cone. These OH groups can be functionalized. Because of the presence of so many OH groups on ether side, cyclodextrins are highly soluble in water which is a big advantage for applications.



This inside is hydrophobic in nature. So, if you take a molecule and do a specific reaction that can be easily done. Once the compound is mixed with a CD the hydrophobic part can go in exposing the functional part to a reagent for a desired reaction to happen. This is supramolecular catalysis.

This cyclic sugars can be obtained from plants. We take starch isolate starch from plant and then apply CGT and we can get this cyclodextrins. We separate them because their sizes are different and after we do that we can derivatize it. We can derivatize these OH groups partially and allow a reaction to happen with other remaining OH groups. When we compare with cucurbituril that have also a hydrophobic cavity with hydrophilic ends, we find that Cucurbiturils are very difficult to synthesize and will be much more expensive. A great advantage of cyclodextrins are that they are highly soluble in water. In the next class, I will be discussing what is called dendrimers. And then we proceed, we are going to more and more complex systems as we move. Thank you very much.