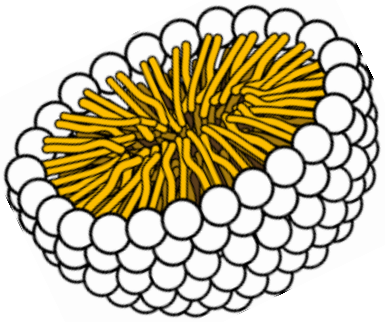
Micelles in Smart Drug Delivery System



Source: https://commons.wikimedia.org/wiki/File:Phospholipids_aqueous_solution_structures.svg

Polymeric micelles are a combination of amphipathic molecules and reactive polymers. They are used as a vehicle to carry drugs that have least solubility. This method can be controlled to alter the size of the micelle produced or the amount of drug to be delivered.
Surfactants or surface-active agents reduce the surface tension of liquids to which they are added. These molecules are usually made of a water-loving (hydrophilic) or a polar head and a water-hating (hydrophobic) or a non polar tail. Due to their partial polar and partial non polar character, these molecules are referred to as amphiphilic or amphipathic. Depending on the charge they carry, they can be anionic, cationic, or ampholytic. They may include detergents (like sodium dodecyl sulfate), emulsifying agents, wetting agents, and foaming agents.

When these amphiphilic molecules are dispersed in polar solvents, they form aggregates called micelles.

Structure of Micelle

Micelles are formed by the aggregation of amphipathic molecules in polar solvents, like water. They are usually in the form of a sphere, sometimes they are in an ellipsoidal or cylindrical form; with the polar heads on the outside and the non polar tails on the inside.

There are some cases(Inverse Micelles), where the molecules orient themselves in such a way that the hydrophilic heads of the molecule are in close contact with the polar medium (water); whereas, their hydrophobic regions are away from it.

Unlike lipid bilayers, micelles are usually composed of only a single layer of molecules. Here, the molecules consist of only a single hydrophobic tail that are held together with the help of hydrophobic interactions between them. The polar heads form hydrogen bonds with the surrounding medium. These molecules are so arranged that they exclude any water molecules from the center.
When the amphipathic molecules are dispersed in a hydrophobic medium, there is formation of a reverse micelle. Here, the molecules orient themselves in such a way that hydrophobic tails are in contact with the surrounding medium, and the polar head are tucked inside, away from the medium. These molecules are usually arranged in such a way that they carry a water molecule in the center.

 Funded by EU under the Erasmus+ KA2 grant N° 2014-1-IT02-KA201-003604_3.

Mechanism of Micelle Formation

Formation of micelles takes place beyond a particular concentration of the amphipathic molecules. This threshold is called Critical Micelle Concentration (CMC). When the concentration of the molecules is much below the CMC, there is slight increase in the entropy of the system, these molecules exist as monomers. The entropy of the system increases with increase in the concentration of the amphipathic molecules.

When the concentration of the molecules is just below the CMC, the molecules sort of aggregate and give rise to premicellar structures.

When the concentration of the molecules is increased to or just above CMC, the molecules orient themselves in such a way that entropy of the system is decreased considerably, and micelles are formed. The entropy of the system is further reduced by the presence of counter-ions.

Factors Affecting Formation of Micelles

Ideally, micelles vary in size from 2 nm to 20 nm, depending on their number and composition. Besides CMC, there are other factors that may influence the rate of micelle formation.
Temperature: Micelle formation can take place only above a particular temperature. Krafft temperature is the minimum temperature at which these amphipathic molecules form micelles. Below this temperature, molecules remain in a crystalline form.
Concentration of Counter-ions: In a polar medium like water, the number of counter-ions is always equal to its degree of binding to the micelle. As counter-ions bind to polar heads of the amphipathic molecules, they decrease the repulsion between them, and thus, increase the stability of micelles. The CMC decreases with the increase in the number of counter-ions.

Function of Micelles in the Body

Micelles aid in the absorptions of lipid molecules as well as fat soluble vitamins. After digestion, fatty acids form micelles with bile acids. These micelles are necessary for the uptake of fatty acids by the intestinal cells as fatty acids are insoluble in water. Micelles are also required for the uptake of fat soluble vitamins and cholesterol as well.

Micelles in Detergents

 Funded by EU under the Erasmus+ KA2 grant N° 2014-1-IT02-KA201-003604_3.

Detergents are capable of forming micelles. These micelles function as emulsifiers, as they dissolve substances that are usually insoluble in water. The hydrophobic tails of detergents interact with insoluble dirt and oil such that, the dirt is entrapped in the hydrophobic center of these micelles. Washing of clothes with water will remove these dirt particles entrapped in micelles and clean the surface.
These days, micelles have a wide range of applications in textile industry, medicine, and biological research.

Source: http://www.buzzle.com/articles/micelle-function-structure-and-formation.html

Co-funded by the Erasmus+ Programme of the European Union

This project has received funding from the European Union's Erasmus + Programme for Education under KA2 grant 2014-1-IT02-KA201-003604. The European Commission support for the production of these didactical materials does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

