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Review in The Biological applications of glycolipids liquid crystals

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Abstract:
Glycolipids are essential components in the most living systems cells. They can playing different roles and activities inside and outside the bilayer membrane that surrounding the cells. They consider as biosurfactants because their structure that is contain polar head groups and the other accompany part the non-polar long-chain alcohols. In this context, these bio-surfactants can found in different phases in lyotropic liquid crystalline properties and therefore, many actions that related to these phases can offer a wide-range of roles like antibacterial, antifungal anti-cancer and antenna for most recognition of the materials that affected the cell membranes.

1. Introduction:

The cell is the smallest form of life, which consider as a building block, whatever the organism consist of one or large number of cells. The components of cells are act different actions to serve particular roles. The simple description of cell is a certain constituents that surrounding with bilayers phospholipids as well as other materials to form a membrane. All the transports functions in or outside the cell is perform through the membrane with external media.[1] The glycolipids GLs are essential material of membrane that contribute in several activities in the cell. The GLs in few cases are associated with certain diseases, i.e., a mutation of glycosyl ceramide in spleen can cause disease called Gaucher, which is also occur in case of glucocerecroside mutation in kidneys. This is an inborn ill is found when there is lack in enzyme known as glycocerebrosidase which is in charge of storage of lysosomes. According to the information above, the GLs are studied extensively to understands the basic properties which may help reveal some biological ambiguities.[2] Moreover, The self-assemble capacity of GLs in arouses environment responsible for the biological activities of such procurers . One example is the liquid crystalline behavior as an application to form nano-scale materials. In the other hand, the self-assembly of GLs substances is decide where to employ these materials in biological or industrial fields.[3], [4] The connection of sugar moieties with a aliphatic lipids by covalent bond can produce a GLs.[5]. Experimentally, the glycolipids are capable of self-assemble in dry system (thermotropic) as well as solvated phase (lyotropic) to form a variety of polymorphic phases depending on appropriate situations.[6] The glycolipids resources is verified from the collection from living species, for example the sponges from marine , or can be synthesized from different starting materials in the laboratory. [7]

2. Glycolipids classifications

The GLs can be classified according to the source of production into two main classes:

2.1 Natural Glycolipids

The plant and mammal as well as microorganism are consist of natural GLs in their tissues.[8] Normally, They are found mostly on the outer of cell membranes and look as if play four wide functions, containing stabilization, shape determination, recognition and ion association (Figure Error! **No text of specified style in document.**-1). The glycolipids with phospholipids represent the major components of cell membrane [9] .

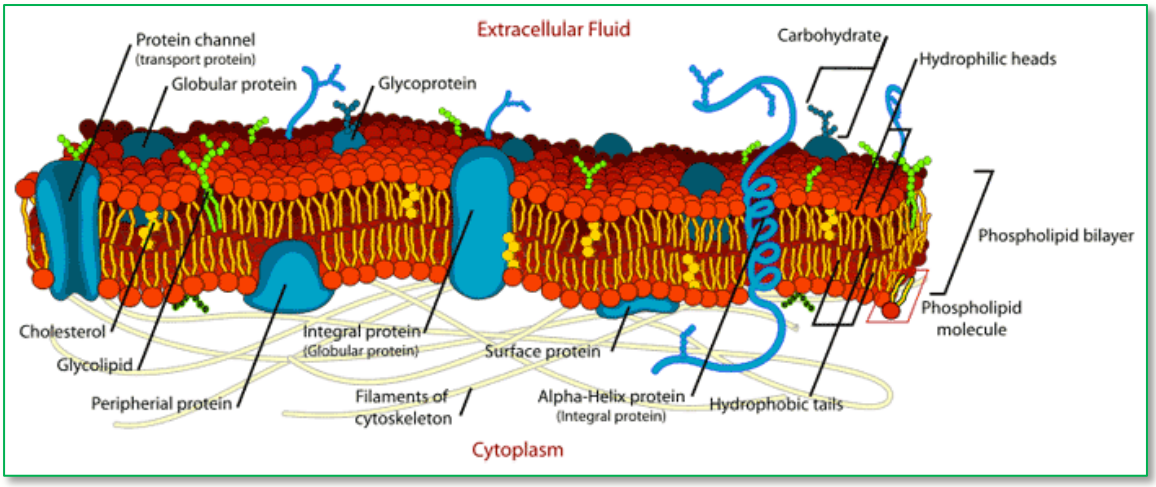

Figure Error! No text of specified style in document.**-1: Cell membrane components**

Natural GLs formed from two parts the sugar units that attached directly to other lipid units, in which, the sugar head group distribute in aqueous media while the lipid mieoties spread in the membrane wall. [10] The natural glycolipids having one of the three types of functional groups, either an ester, an ether or an amide that is fundamentally significant to the aqueous environments and ion binding capability of this amphiphilic molecules [11].

2.2 Synthetic Glycolipids

There are diffectulties accompany the purification and extraction of neutrally glycolipids due to long time and tedious procedures requierments from nature. However, trying to synthesis such natural materials is challenge, that shift the attention to use a man-made alternatives which is required simple procedures and easy to investigate the synthetic materials in biology.[12] Besides, the synthetic glyclolipids are compatible to the environments, biodegradable and less fatal, so they are largely applied in many productions. [13]. In addition, glycolipids may illustration varied liquid crystalline behaviors built on the creation of diverse meso phases through several aspects such as varying temperature as well as concentration. [14].
Certainly, saccharides with their several hydroxyl groups in individual configurations, advocate a forecourt for chemists to search the impact of substituted moieties on their

properties, generally those associated with hydrogen bonding systems and polarity issues [15]. In addition, the type of the chemical linker (-O- or CO or CONH) lets the structure of a enormous total of different glycolipid backbones. Figure 2, showed A some examples of pepared glycolipids are presented. [16]

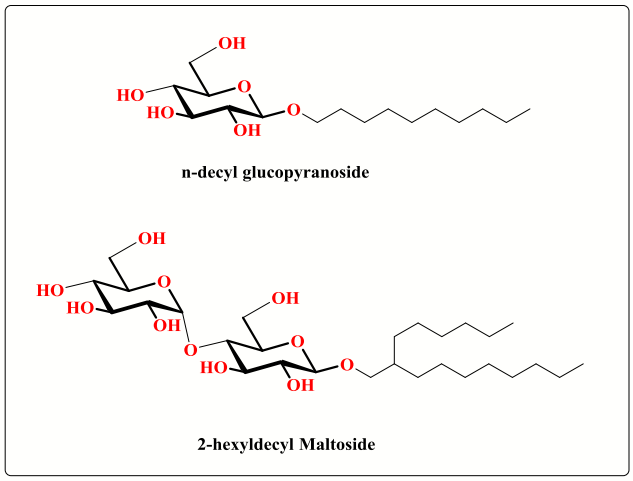

Figure 2: A few examples of synthetic glycolipids

3. Liquid crystalline glycolipid

The glycolipid amphiphile as liquid crystal was historically began when the scientist Emil Fishcher and Helferich notification about two melting point for n-hexadecyl glucoside. [5]

This finding was deliberate the beginning of thermotropic liquid crystalline on such materials , i.e., the glycolipids. The mesophase found in scharides structure is responsilbe for different change between the two incompatible polarity material, i.e, amphiphiles. When the polar side (sugar) is formed hydrogen bonding along head group, while the tail of hydrocarbons is interact less strong by common Van der Walls interaction.[17]

3.1 General Descriptions of Liquid Crystals

Liquid crystals are defined nowadays as materials in phases between the properties of solid and liquid.[9]. In other words, in a certain liquid crystal phase they have specific degree of order coordination in three dimensions [15] The research areas are allocated with two main fields:

a. the life science
b. material science

However, the area of specific research on liquid crystals is not constrained to any of these area of investigation, and it is certainly interdisciplinary in all of its features. [18].

3.1.1 Head Group

The glycolipids can offer a water like head group by modification of the hydroxyl on the head group, i.e. sugar moieties. An example of that is production of different glycosides with long chain alcohol in form of either α or β linkage, so the physical

and chemical properties will verified.[19]. Skaya et. al., studied the behaviors of phases of glycolipids thermo and lyotropic liquid crystal phases of different single chain glycoside of galacto, manno and glucoside(Fig 3). Their studies reveal that even simple play around with head groups can give a significant variety of behavior in liquid crystals.[20]

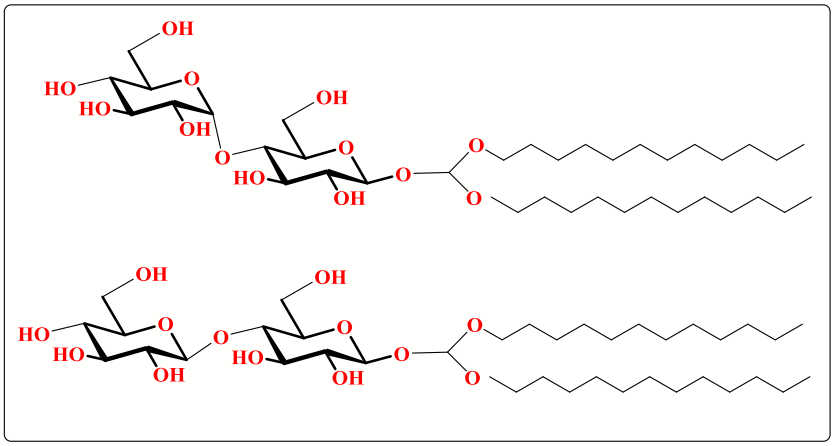

Figure 3: glycerols bearing a series of (a) malto-a nd (b) cellobiose .

The modification of head group studied via sabah et.al., by modified the head group of monosaccharides with crown ether in different ring sizes (Fig 4). They studied as well the sodium and potassium associated with increasing of solubility via crown ethers. [21]

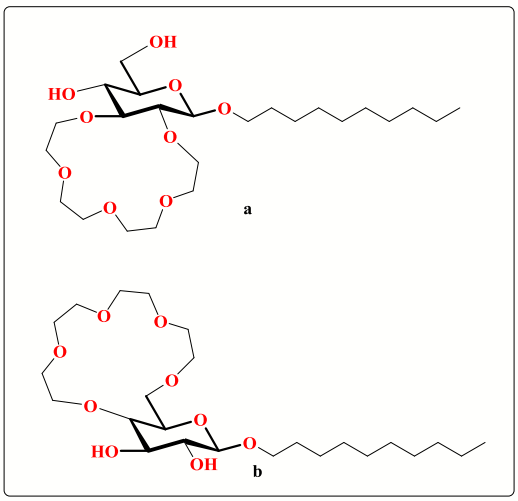

Figure 4: crown ether moiety of (a) 2, and 3 positions and (b)4 and 6 position on glucopyranoside..

Also, some studied on the modification on C-6 have been reported by Cook research group when they synthesized an long chain ester of carboxylic acid with hydroxyl group on 6 position. The chain lengh is verified from 12 to 16 carbons, (Fig. 5).[22]

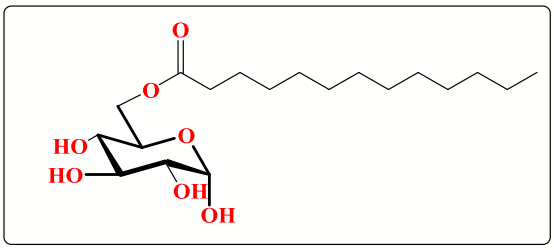

Figure 5: The ester on 6 position of glucoside .

3.1.2 Hydrocarbon Chain

The hydrocarbon tail on glycolipids can be aslo modified in such a way that show a significant change in liquid crystalline behavior. For example, the straight chain of hydrocarbon influence the hydrophilic hydrophobic balace when increase in length and exhibit a higher thermo or lyotropic form..[23]

The branch chain hydrocarbon on the tial of glyclolipids have been studied by Hashim et. al, when they investigated the influence of several mono and disacchrides. The study comes with good result that both thermo and lyotropic structure of the glycolipids is behave similar to the straight chain in liquid crystalline behaviour in packing parmeters and then different phases can be obtained. [24]

4. Categories of Liquid Crystals

Principally, , Liquid crystals are distributed into two main categories; thermotropic liquid crystals and lyotropic liquid crystals. The class namely thermotropic contributed phase transition after temperature is wide-ranging. While the second category called lyotropic liquid crystals display phase transition with the variable the quantity of the materials in certain solvent. However, the liquid crystals of glycolipids are considered as"amphitropic" as they can display both lyotropic and a thermotropic LCs phase in solvent and dry form with vibration of temperature respectively.[25]

4.1 Thermotropic Liquid Crystals

The materials when domenstated a phases of liquid crystalline on heating or sometimes cooling are called thermotropic liquid cyrstals. Normally, the thermotropic liquid crystal is made when temperature higher slightly than melting point (Tm) and the solid. The continues increasing of the temperature can enforce the liquid crystal phase changes to isotropic liquid phase, and this temperature at isotropic state is known as the clearing point (Tc).[26]

4.2 Lyotropic Liquid Crystals

The liquid crystalline lyotropic class is formed when the amphiphile substances is mixed with a convinced solvent. The liquid is added to the hydrophilic area of compounds or in the hydrophobic area, which modified the volume ratio of microphases. In the other hand, the organization of phase can be affected by solvent penetration considerably.[27] The lyotropic phases of carbohydrate compounds have a comprehensive and widespread applications in numerous research fields, based on their extremely biocompatibility to the environs, less poisonous and biodegradable

substances.[28] The applications of these materials cover but not narrow to the cosmetics manufacturing, pharmaceutical as drug-delivery constituents, the food industries, in situ templating and the proteins recrystallization of membrane. The best public example of lyotropic phases is the mixtures of soaps and aqueous media. [29]
There are some phases are represented the lyotropic liquid crystalline materials are describe briefly below:

4.2.1 Micelle phase

The simple form of micelle is found when two regions include hydrophilic and hydrophobic is exist on the molecules, in which self-assembly in the solvent exhibit amphiphilic behavior. [30]
The amphiphile formed in the polar solvent micelles in which the polar head group surrounded by the polar part of the solvent (hydrophilic) while the hydrophobic part is go inside the micelles. In non-polar solvents the opposite is occur and reverse micelles will formed (Figure 6).[31]

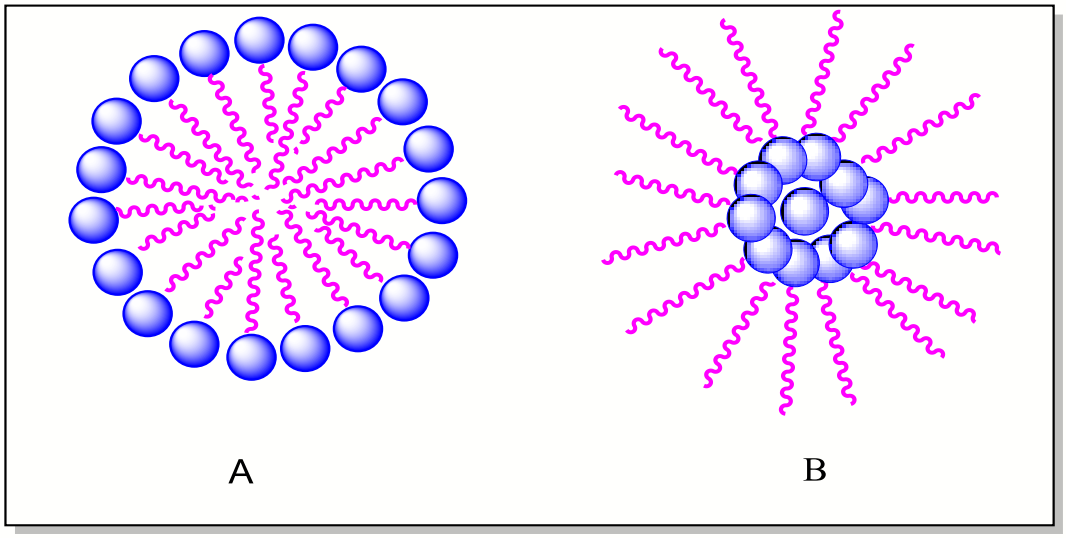

Figure 6: (a) normal micelles and (b) inverse micelles.

4.2.2 The Lamellar (Lα) phase

The structure of lamellar in lyotropic phase is consist of repetitive units of bilayers which normally separated by the solvent molecules (Figure 7). The polar head parts (hydrophilic) of the amphiphile are cotacted with water molecules while the long chain (hydrophobic) component are hide faraway from water. .[32]

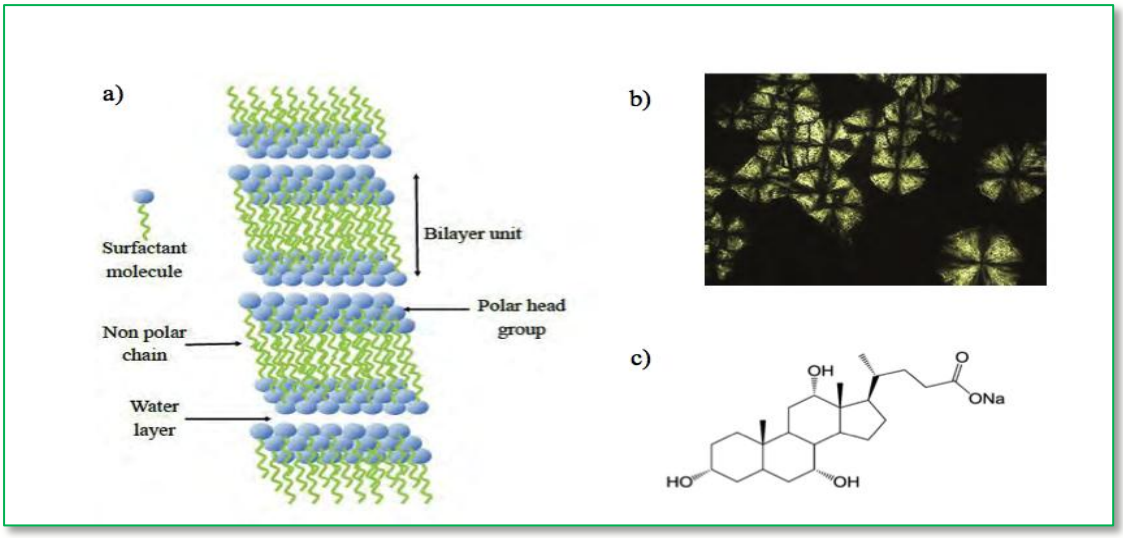

Figure 7: : Examples of bilayers lamellar (Lα) phase.

4.2.3 The cubic phase

Two classes of cubic phase are consist a two catergaries called either bicontinuous phase when it formed triply periodic minimal surfaces, or discontinuous cubic depending upon the packing of discrete aggregation of micellar in complex ways.[33]

4.2.3.1 bicontinuous cubic phase

The amphiphile bicontinuous cubic phase could be classified into either direct (normal) in which the water film in located in the center of triply periodic minimal serface and the surfactant filled the dis-joint spaces .[34] , or inverse phase when the surfactant bilayers are occupied the triply periodic minimal surface (figure 8). .[35]

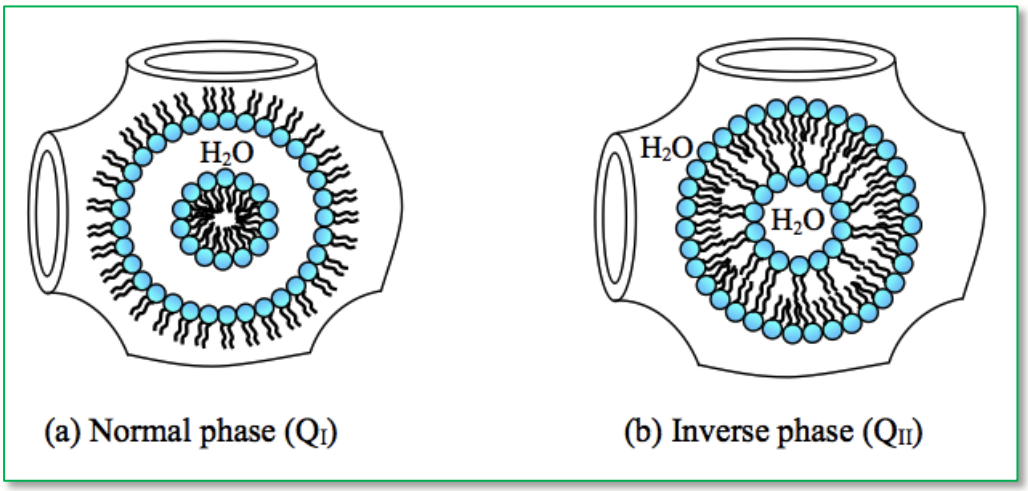

Figure 8: The bi-continuous cubic phase of the molecule.

4.2.3.2 Discontinuous cubic phase

The discontinuous cubic phase in hydrophobic/hydrophilic systems is found with structures consisted of spherical aggregation of types lipid in water or water in lipid. Indeed this brilliant construction may be employed in drug delivery systems. The biological systems have a good examples of containing discontinuous cubic phases when the aggregation of micelles are filled in cubic assortment (Figure 9).[36]

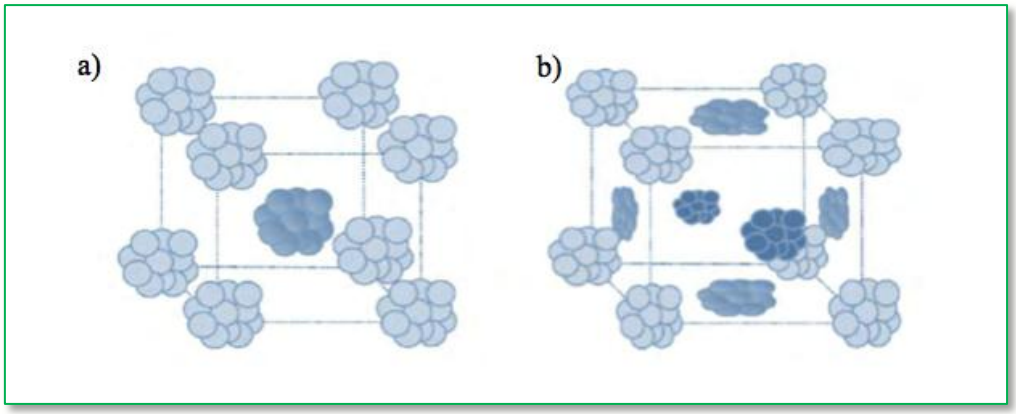

Figure 9: Discontinuous cubic (a) body-centered cubic and (b) face-centered cubic.

4.2.4 Hexagonal phase

As referred from its names, this phase (hexagonal) possess aggregation of molecules that organizing according to the hexagonal shape (figure 10). However, two types of this phase is found in liquid crystalline materials, one is named normal hexagonal (referred as H1) and the other is inversed hexagonal (known as H2). The former (H1) is arranged in shape of rods of indefinite length organized in hexagonal phase in water (figure 10). In inverse hexagonal phase, the polar parts point interior into the water network whereas the hydrophobic ends are directed external.[37]

The H1 and H2 phases could be more stable even in the excess of aqueous solutions and based on this can be form a nanoparticles that dispersed in water and finally are useful for releasing some drugs in controlled drug delivery systems. .[38]

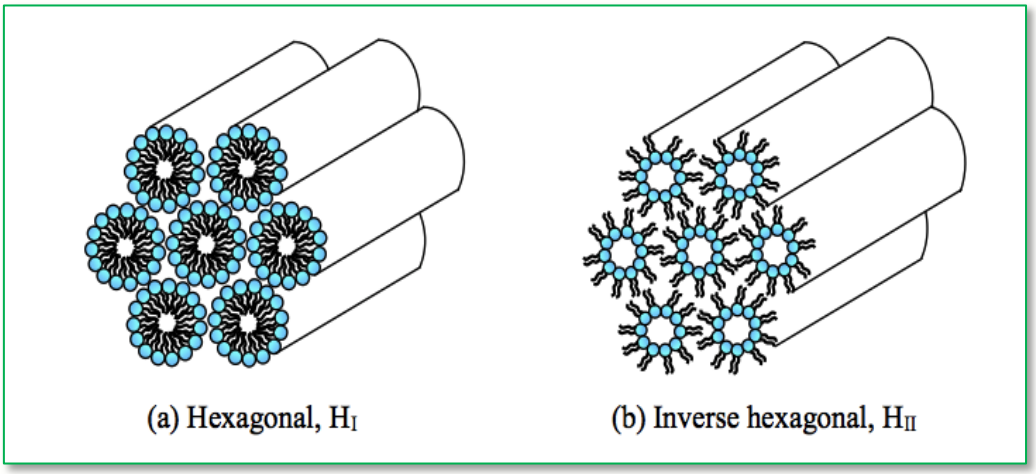

Figure 10: Schematic structures of hexagonal phases.

5. Application of Glycolipids biomedical manufacturing

5.1. Membrane application of glycolipids

The properties of certain materials (biosurfactants) to form pore and form some channels for ions in the bilayer membrane are very important as permeabilization, because of their ability to weaken the membrane spreading.

Some of glycolipid surfactants are of interest as pharmaceutics due their biomedical properties like antibacterial agents, anti-tumors and hemolytic activity. For example,

rhamnolipids and trehalose lipids that, they extracted from two bacteria *Pseudomonas* and *Rhodococcus* respectively are found to organize the pore formation ability in the membrane permeabilization actions. These actions enable the usage of these biosurfactatnts in several disciplines exclusively as biocontrol agent in agriculatural fields, as preservation agent to control infectious in food manufacturing and so on.

5.2 Anti-bacterial Properties of Glycolipid bio surfactants

The rhamolipids drevative of *P.aeruginosa* antibacterial actions are extensively studied in various reports to explain the potency of permeabilizing of the surface actions on the membrane of becteria. For instance, Benincasa and coworkers reported a reasonable antibacterial actions of the rhamnolipids that extracted from *P. aeruginosa* towards different types of bacteria in the range of 8 µg/L for *Staphylococcus* and 4 µg/ L for *Sterptococcus.*

5.3. Antifungal Glycolipids biosurfactants

The previous research reports were refer that rhamnolipid that extracted from P. aeruginosa and mannosylerythriollipid are very candidate to act as antifungal agents due to their activities towards several fungi.

These glycolipids displayed a extensive range of antifungal properties to the fungi called *phytopathogenic* and open the door to use them as plant protective agents in agriculture field.

5.4. hemolytic Glycolipids biosurfactants.

The hemolytic activity are well known for the glycolipids biosurfactants like rhamnolipid . The group research led by Sanchez and his coworkers wrote about the potential activities of permealbilization of birahmanolipid that obtained from becteria especially *P. aeruginosa* . Therefore, these are necessarily involve the leakage of vesicular consistents, erythrocyte hemolysis and some morphological changes in human-being erythrocyte. However, the relasing of carboxy-fluorescein in the interior content could reflect the leakage that involved in the dirhamanolipid actions.

5.5. Antiviral Activity of Gycolipid biosurfactants

The glyclolipids have beside their antibacterial and antifungal activities another activities towards several viruses, i.e. antiviral. Many of glycolipids based rhamnose sugar have been investigated extensively over several decades and reveal good antiviral activities aginst viral replication. In this context , Remichokova and his coworkers indicate that cruel effects of rahmanolipid substance on HSV replication can affected by dose depending upon the concentration below CMC critical micelle concentration of biosurfactant. In addition, the rahmnolipids are argued for regulatory viral infection in reap plants. On these bases, rhamnolipids were positively applied for cure of Nicotiana glutinosa leaves diseasaed by Tobacco virus.

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