# Gyroid Minimal Surface as Proton Conduction Pathway

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Bicontinuous cubic ($Cub_{bi}$) phase is a kind of nano-segregated liquid-crystalline (LC) phases in which both of two incompatible molecular parts form 3D continuous domains.[1] It has been found that $Cub_{bi}$ phases appear between lamellar and columnar phases both in the case of lyotropic liquid crystals and thermotropic ones. The volume balance between the two incompatible parts is one of the critical parameters for designing liquid crystals forming $Cub_{bi}$ LC assemblies. To date, we have focused on ionic liquid crystals having zwitterionic headgroups.[2,3] For example, we designed and synthesized pyridinium-based amphiphiles having zwitterionic headgroups. Although it forms only layered smectic phases in the pristine states, it co-organized into $Cub_{bi}$ LC phases in the presence of bis(trifluoromethane)sulfonimide ($HTf_2N$).[3] It can be explained by the formation of ion pairs between the pyridinium zwitterion part and $HTf_2N$ through an ion exchange and the increase of the volume of the ionic parts. The $Cub_{bi}$ LC assemblies have a hydrophilic gyroid minimal surface where sulfonate group sit on densely and periodically. When a suitable amount of water is added to the $Cub_{bi}$ LC assemblies, a 3D continuous water nanosheet is created, which function as proton conduction pathway.

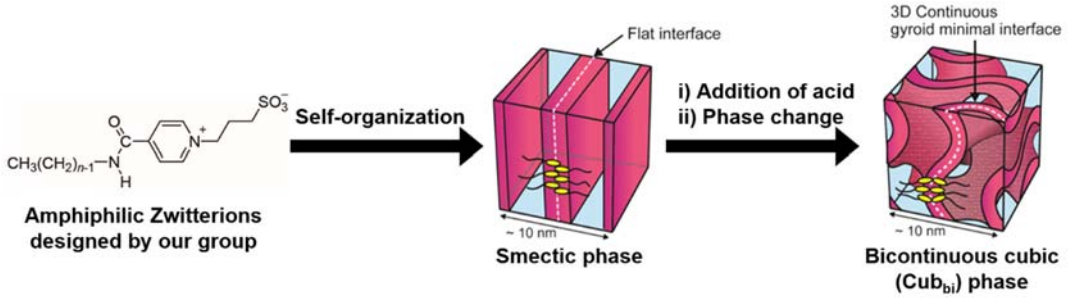


**Figure 1**. Induction of bicontinuous cubic phases for amphiphilic zwitterions.

Based on the molecular design of the amphiphilic zwitterions, we have recently succeeded in the development of a gemini-type amphiphilic zwitterion monomer forming $Cub_{bi}$ phases.[4] UV irradiation for the monomer in $Cub_{bi}$ phases leads to the formation of self-standing and insoluble polymer films with preserving the gyroid nanostructures. The polymer film shows quite high proton conductivity in the order of $10^{-2}$ S cm$^{-1}$ in the $H_2O$-absorbed condition.

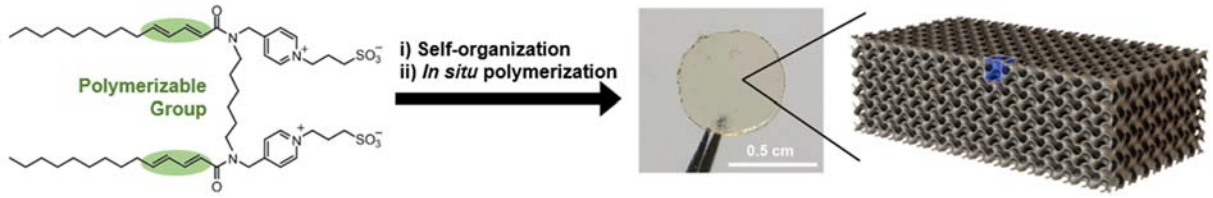


**Figure 2**. Design of gyroid nanostructured polymer films using a polymerizable amphiphilic zwitterion.

**References**

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