Tuning the Surface Wettability of Alumina Membrane for Carbonate Crystallization

CNF Project Number: 2983-21
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Primary Source(s) of Research Funding: National Science Foundation Faculty Early Career Development Program (NSF CAREER)

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Primary CNF Tools Used: Ramé-Hart Contact Angle Goniometer 500

Abstract:

Uncovering the nucleation and crystallization of calcium- and magnesium-carbonate in confined nanochannels is pivotal in interpreting the polymorph formation and stabilization in various physicochemical conditions having applications ranging from carbon sequestration to construction, plastics, and pharmaceuticals [1-3]. These carbonates exhibit anomalous physical and chemical phenomena due to finite size effects, and ionic effects altering their energies and kinetics of phase formation [4]. Accounting for these effects, the current research focuses on precipitating calcium- and magnesium-carbonate in confined alumina membranes and siliceous nanochannels having discrete pore sizes. Specifically, to account for the influence of surface wettability on carbonate growth, the alumina and siliceous nanochannels are transformed from hydrophilic to hydrophobic. This variation in surface wettability provides insights into the role of interfacial water on the growth/dissolution of carbonates. To probe and corroborate the synthesis of hydrophilic nanochannels into hydrophobic, a contact angle measurer was utilized and the mean contact angle of the hydrophilic and hydrophobic nanochannels was measured as 23.9° and 93.9°.

Summary of the Research:

Understanding the influence of variation in surface wettability on carbonate growth and phase evolution is crucial and to alter the surface wettability the purchased anodic alumina membrane is first rinsed with ethanol and water and dried at 85°C for 30 minutes. Thereafter, the membranes were immersed in a solution of lauric acid in ethanol (20 g/L) for 15 minutes at 50°C and stirred at 120 rpm. The surface-modified membranes were again rinsed with ethanol and DI water and dried at 85°C for 30 minutes. This surface-altering process replaces the hydroxide moieties attached to the aluminum ion with lauric acid.

Contact angle measurement was performed using Ramé-Hart Contact Angle Goniometer 500 having a volume step of 10 .L and delay time of 4000 milliseconds to determine the surface wettability of the hydrophilic and hydrophobic surface. The contact angles measured were 23.6°, and 24.3° for the left side (.) and right side (.') of the droplet respectively

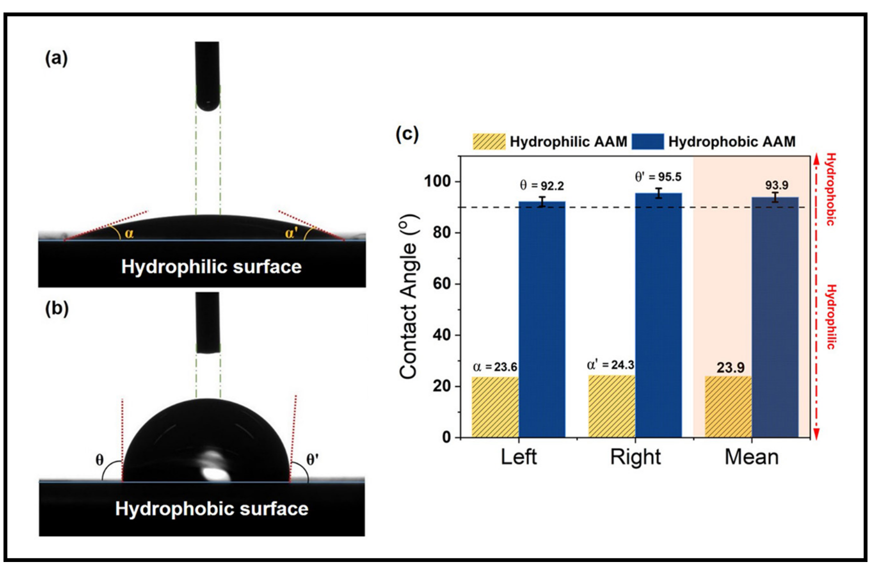

Figure 1: Contact droplet angles.

for the hydrophilic membrane and 92.2°, and 95.5° for the left side (.), and right side (.') of the droplet respectively for the hydrophobic membrane as shown in Figure 1. The mean contact angles were 23.9° and 93.9° for hydrophilic and hydrophobic anodic alumina membrane respectively. Based on the analysis, synthesis of the membrane from hydrophilic to hydrophobic was accomplished.

Conclusion and Future Steps:

The behavior of fluids in nanoconfinement is an intricate mechanism characterized by anomalous phase behavior, spatial density profiles, and unique ion transport dynamics [4,5]. In this research, a similar mechanism is studied by analyzing the evolution of calcium- and magnesium-carbonate in nanoconfinement in different surface wettability environments. Before analyzing the phase evolution, synthesizing hydrophilic membranes into hydrophobic was performed using lauric acid, and to corroborate the hydrophobicity, a contact angle measurement was performed. The mean contact angle for the hydrophobic membrane attained was 93.9° validating the synthesis approach.

The future steps involve the transformation of anodic alumina membranes using lauric acid of different pore sizes and investigating the intricate relation between pore size and surface contact angle. Furthermore, the surface of silica nanochannels will be modified into hydrophobic using agents like sodium dodecyl sulfate (SDS), ethanol, methanol, etc. [6,7], and the contact angle for these membranes will be measured.

References:

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