

Modulating coalescence timing of liquid marbles via wettability adaptation

*Chittaranjan Mishra*¹, *Debasmita Sarkar*¹, *Nishanta Barman*¹, *Saurav Kumar*¹, *Mizuki Tenjimbayashi*^{*2} and *Uttam Manna*^{*1,3}

¹ *Department of Chemistry, Indian Institute of Technology-Guwahati, Kamrup, Assam 781039, India*

² *International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS), Japan*

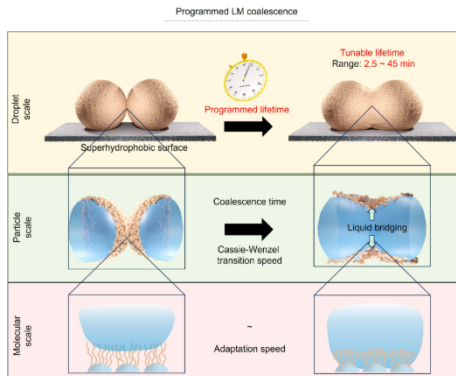
³ *Centre for Nanotechnology, Indian Institute of Technology Guwahati, Kamrup, Assam 781039, India*

c.mishra@iitg.ac.in

Droplet coalescence is a common phenomenon in nature, playing an important role in various industrial and biomedical applications. While uncoated droplets merge upon contact, droplets that are covered with liquid-repellent particles known as “liquid marbles (LMs)” do not coalesce in the same way. Previous work has explored how the particle layer can be triggered to break using external stimuli to control the timing of coalescence. However, programming the timing of droplet coalescence without such stimuli has been difficult. In this study, we present LMs designed to break their particle layers at pre-set times. The particles have a core that is wettable and are connected to a low-wettability flexible molecular chain that gradually increases in wettability over time. This time-dependent change in wettability arises from how the molecular chain adapts, making it a repeatable process whose speed can be managed by adjusting the chain length. As a result, these LMs can reveal their bare droplet surfaces at predetermined times, allowing control over coalescence from 2 to 45 minutes without needing external stimuli. Additionally, the ability to combine the particles allows for precise adjustments of the coalescence timing, achieving resolutions of about one minute. Moreover, the interaction between multiple LMs with varying adaptation times facilitates cascade droplet coalescence, paving the way for new methods of droplet manipulation.

Keywords:

Automated coalescence, wettability adaptation, liquid marble, chemical modifications, 1,4-conjugate addition reaction



Scheme depicting the automated coalescence of LM on a superhydrophobic surface with a programmed coalescence time, where Cassie-Wenzel transitional speed in particle scale and water adaption in molecular scale influenced the coalescence time of LMs.

References:

- [1] H.-J. Butt, R. Berger, W. Steffen, D. Vollmer, S. A. L. Weber, *Langmuir* **2018**, *34*, 11292.
- [2] Aussillous, D. Quéré, *Nature* **2001**, *411*, 924.
- [3] Tenjimbayashi, T. Mousterde, P. K. Roy, K. Uto, *Nanoscale* **2023**, *15*, 18980.