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Communication

Self-Propelled Aero-GaN Based Liquid Marbles Exhibiting Pulsed Rotation on the Water Surface

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Abstract: We report on self-propelled rotating liquid marbles fabricated using droplets of alcoholic solution encapsulated in hollow microtetrapods of GaN with hydrophilic free ends of their arms and hydrophobic lateral walls. Apart from stationary rotation, elongated-spheroid-like liquid marbles were found, for the first time, to exhibit pulsed rotation on water surfaces characterized by a threshold speed of rotation, which increased with the weight of the liquid marble while the frequency of pulses proved to decrease. To throw light upon the unusual behavior of the developed self-propelled liquid marbles, we propose a model which takes into account skimming of the liquid marbles over the water surface similar to that inherent to flying water lily beetle and the so-called helicopter effect, causing a liquid marble to rise above the level of the water surface when rotating.

Keywords: aerogalnite; aero-GaN; liquid marble; pulsed rotation

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1. Introduction

Liquid marbles, discovered by Aussillous and Quéré in 2001 [1], represent aggregates composed of a droplet of liquid encased in and stabilized by a shell of nano- and/or microparticles which, in most cases, possess hydrophobic properties. Honeydew droplets coated by powdery hydrophobic wax secreted by aphids are considered as natural analogous of liquid marbles (LM) [2]. Among specific characteristics inherent to liquid marbles which attracted increasing attention of the scientific community, one can mention permeability of their shell to gases, elasticity, stability on solid and liquid surfaces, along with non-wetting behavior and the ability to non-stick on solid surfaces. Liquid marbles, also known as "dry waters", demonstrated huge potential for use in microfluidics for controlled transport and release of the small quantities of liquids as well as in sensorics [3,4], microrobotics [5,6], biomedicine [7,8], etc. In particular, Han et al. [9,10] reported on precise control over mass transportation and distribution in the droplet of the liquid marbles synchronously rotating with an external magnetic field, thus opening opportunities for the development of various micromagneto-mechanical devices for use in microfluidics.

In the last decade, research efforts have been undertaken to develop self-propelled liquid marbles exhibiting translational motion, rotation or their combination, self-propulsion