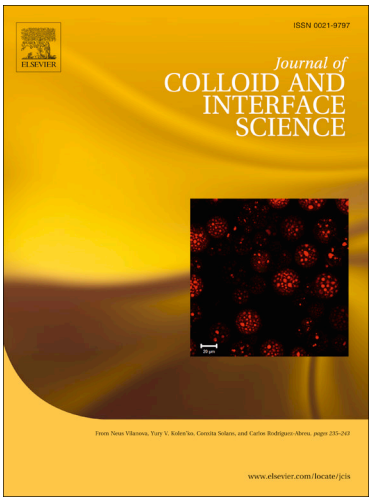

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Cracks in dried deposits of hematite ellipsoids: Interplay between magnetic and hydrodynamic torques

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Abstract

The orientation and morphology of cracks in coffee-ring like particulate deposit obtained by drying sessile drops containing anisotropic magnetic particles strongly depends on the magnitude of the applied magnetic field and its direction. This opens up the possibility of tuning the micro-structure of cracks via suitable manipulation of magnetic and hydrodynamic torques on the particles which has potential applications in nano-fabrication and field driven self-assembly. We report a systematic study of magnetic field driven self-assembly of hematite ellipsoids in sessile drops dried on solid substrates and resulting crack patterns. The experiments are carried out over a wide range of applied magnetic field strength ($|\vec{B}|$) varying from 0-400 G and ellipsoids of two different aspect ratios. Dried coffee-ring deposits of ellipsoids in absence of the external applied magnetic field and at low field strength, $|\vec{B}| <$ 20 G exhibit circular cracks. However, at $|\vec{B}| \geq 30$ G, the cracks are observed to be linear and perpendicular to the direction of the applied magnetic field. Random cracks are observed in the intermediate field range of 20 G $< |\vec{B}| <$ 30 G. Thus our experiments reveal that there exists a critical magnetic field at which the orientation of cracks change from circular to linear. The knowledge of the critical field is exploited to measure the hydrodynamic torque experienced by nano-ellipsoids and fluid velocities during evaporation, which are challenging to measure experimentally.

Keywords: Cracks, Coffee-ring effect, Magnetic torque, Hydrodynamic torque, Critical magnetic field, Ordered cracks.

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