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The breakup mechanism of biomolecular and colloidal aggregates in a shear flow BREANNDÁN Ó CONCHÚIR, ALESSIO ZACCONE, University of Cambridge — The theory of self-assembly of colloidal particles in shear flow is incomplete. Previous analytical approaches have failed to capture the microscopic interplay between diffusion, shear and intermolecular interactions which controls the aggregates fate in shear. In this work we analytically solved the drift-diffusion equation for the breakup rate of a dimer in flow. Then applying rigidity percolation theory, we found that the lifetime of a generic cluster formed under shear is controlled by the typical lifetime of a single bond in its interior, which in turn depends on the efficiency of the stress transmitted from other bonds in the cluster. We showed that aggregate breakup is a thermally-activated process where the activation energy is controlled by the interplay between intermolecular forces and the shear drift, and where structural parameters determine whether cluster fragmentation or surface erosion prevails. In our latest work, we analyzed floppy modes and nonaffine deformations to derive a lower bound on the fractal dimension df below which aggregates are mechanically unstable, ie. for large aggregates df $\simeq$ 2.4. This theoretical framework is in quantitative agreement with experiments and can be used for population balance modeling of colloidal and protein aggregation.

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