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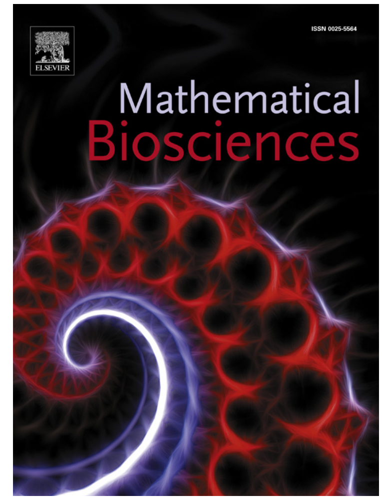


# Impact of flow on ligand-mediated bacterial flocculation

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# Impact of flow on ligand-mediated bacterial flocculation

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**Abstract**

To understand the adhesion-fragmentation dynamics of bacterial aggregates (i.e., flocs), we model the aggregates as two ligand-covered rigid spheres. We develop and investigate a model for the attachment/detachment dynamics in a fluid subject to a homogeneous planar shear-flow. The binding ligands on the surface of the flocs experience attractive and repulsive surface forces in an ionic medium and exhibit finite resistance to rotation (via bond tilting). For certain range of material and fluid parameters, our results predict a nonlinear or hysteretic relationship between the binding/unbinding of the floc surface and the net floc velocity (translational plus rotational velocity). We show that the surface adhesion is promoted by increased fluid flow until a critical value, beyond which the bonds starts to yield. Moreover, adhesion is not promoted in a medium with low ionic strength, or flocs with bigger size or higher binder stiffness. The numerical simulations of floc-aggregate number density studies support these findings.

**Keywords:** adhesion, binding kinetics, micro hydrodynamics, bistability, flocculation, Smoluchowski coagulation equations

# 1 Introduction

The adhesion and fragmentation of particles and particle aggregates is ubiquitous in biological and colloidal process. For example, the binding/unbinding of bacterial clusters to medical implants or host cells in the presence of an external flow is a significant source of bodily infection [1]. Other examples include neutrophils binding to the walls of post-capillary venules in response to infection or injury as part of inflammatory response [2], blood-borne cells sticking to endothelial lining of blood vessels during immune response and cancer cell metastasis [3]. Medical gels coalescing with functionalized particles are candidates for targeted drug delivery [4]. The sticky properties of biological interfaces connected by multiple independent tethers are also presently inspiring the development of novel adhesives mimicking the remarkable properties of beetle and gecko feet [5]. These processes are also important unit operations in colloid-based industries such as pulp and paper-making, mineral and ceramics processing and waste water treatments [6]. Coagulation of rapidly settling aggregates are also used to explain the fate and transport of marine contaminants as well as phytoplankton explosions (also known as an *Algal bloom*) in both deep and shallow water bodies [7].