Oxygen transport and mixing dynamics in thin films of oxytactic microorganisms

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We investigate the dynamics in suspensions of oxytactic swimming microorganisms using two different kinetic models : a gradient-detecting model, in which the swimmers detect local oxygen gradients instantaneously, and a run-and-tumble model, in which the swimmers change their run-and-tumble frequency based on the temporal changes in the oxygen field they sample. Using three-dimensional numerical simulations, we study the behavior of such suspensions in thin liquid films surrounded by oxygen baths on both sides. As the microorganisms consume the dissolved oxygen, gradients form causing them to swim towards the free surfaces where the oxygen concentration is higher. We demonstrate the existence of a transition from quasi-two-dimensional dynamics and pattern formation in thin films to chaotic threedimensional dynamics as film thickness increases. This transition, which was also previously observed in experiments, is shown to be associated with an enhancement of oxygen mixing and transport into the liquid.