Anomalous sedimentation of erythrocytes in dilute solutions

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The understanding of the sedimentation properties of asymmetric objects in an inactive liquid is still far from complete. For example, Caflisch and Luke [1] state that the magnitude of the sedimentation velocity fluctuation of individual objects grows with the size of the system. Moreover, sedimentation of asymmetric objects generally involves rotations and translations of the particles due to drag forces. In irregular objects, with a strong tendency to align with the force of gravity, translation velocities emerge that generate advective terms with nonzero divergence [2,3].

We investigate erythrocytes' sedimentation dynamics in different saline solutions, which strongly tend to self-align [4]. We use Differential Dynamic Microscopy (DDM) to obtain the power spectrum, g(q, t), of a sequence of digital images. g(q, t) is directly related to the intermediate scattering function f(q, t), or temporal density-density time correlation function, which represents a measure of the spatial dynamics of the system on length scales of the order q-1 [5]. We report that the sedimentation process is anomalous, whereby a simple exponential does not describe f(q, t). Instead, in our case, f(q, t) is better described by a stretched exponential. To describe this behavior, we propose a Fractional advection-diffusion equation for the fluctuations of object concentration [2, 6], finding that f(q, t) can be described in terms of the generalized Mittag-Leffler function (Figure 1). Moreover, our model allows us to estimate the objects' effective diffusion coefficient and a parameter associated with the erythrocyte's morphology (Figure 2). Our approach allows us to unambiguously identify changes in the morphology of erythrocytes in different saline solutions, thus opening the possibility of being used in the medical diagnosis of blood diseases as sickle cell anemia.

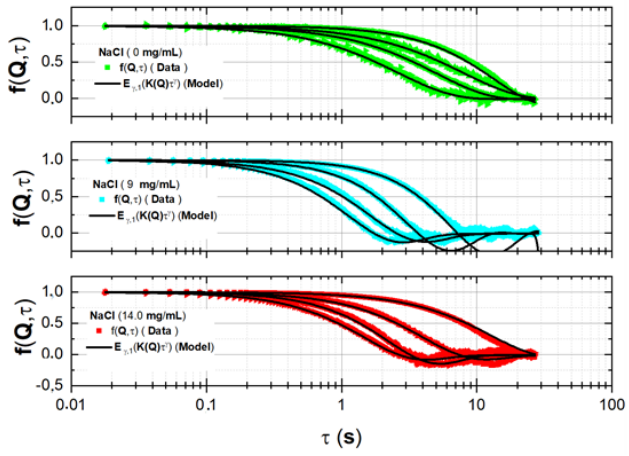

Figure 1

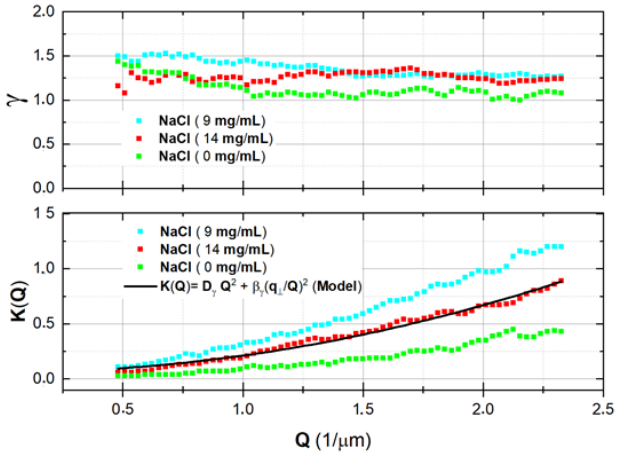

Figure 2

References

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