Abstract Submitted
for the DFD08 Meeting of
The American Physical Society

Complex Dynamics of Vesicles and Red Blood Cells in Viscous Flows PETIA M. VLAHOVSKA, Dartmouth College, GERRIT DANKER, CHAOUQI MISBAH, UJF Grenoble, Laboratoire de Spectrometrie Physique — Closed incompressible membranes exhibit rich behavior in viscous flows. For example, in simple shear flow, vesicles made of lipid bilayers tank-tread, tumble, or breath. Red blood cells also show oscillations in the tank-treading inclination angle. We develop an analytical theory that quantitatively describes this dynamics. Our analysis takes into account that the membrane is deformable, incompressible, and resists bending and shearing. Analytical results for the shape evolution are derived by considering small excess area. In shear flows, the theory predicts that a nearly-spherical closed membrane deforms into a prolate ellipsoid, which tumbles at low shear rates, and exhibits tank-treading accompanied by oscillations in the inclination angle in higher shear rates. The amplitude of the angle oscillations decreases with shear rate. If the viscosity ratio is too high, however, tank-treading never occurs. A comparison to previous work is discussed, namely some approximate models which assume fixed ellipsoidal shape. In quadratic flows, the theory predicts a peculiar coexistence of parachute- and bullet-like vesicle shapes at the flow centerline. Vesicles always migrate towards the flow centerline unlike drops, whose direction of migration depends on the viscosity ratio.

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Date submitted: 04 Aug 2008 Electronic form version 1.4