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Numerical indentation of human red blood cells by carbon nanotube needles

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Human red blood cells (RBCs, also called as erythrocytes) make up a large percentage of the blood volume [1]. They have the capability to undergo extreme deformations and resist rupture because of high membrane elasticity. Studies on Red Blood Cells (RBCs) like abnormal rheological behavior of Sickle cell RBCs [2], stiffness behavior of diseased RBCs [3], hardness and modulus with indentation depth and strain rates [4], effect of smoking on RBCs [5] and mechanical behavior of Malaria infected RBCs, performed have revealed the information about deformation behavior of the RBCs. These are limited to micro-scale analysis but are yet to consider the nano-indentation behaviour using CNT (Figure 1) [6]. In the present work, a detailed study on understanding the hyper-elastic response of RBCs to nano-indentation is presented. It is one of the essential features in design mechanisms required for effective drug delivery. A Finite Element Analysis (FEA) of nano-indentation of human RBC membranes is performed using Carbon Nano Tube (CNT) needles (Figure 2). Indentation response behaviour of the RBCs is analyzed and presented for different boundary/loading conditions. Different types of CNTs are considered. It is expected the present approach will help in the process of designing effective drug delivery mechanisms capable of targeting individual RBCs and understand their response to nano-scale indentation.

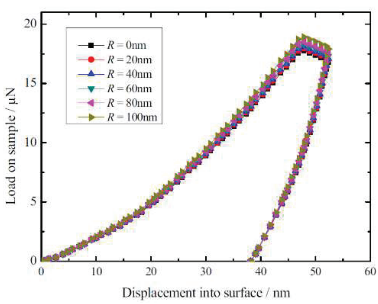

Figure 1: Load vs. displacement curves for various indentation tip radii of a Berkovich type indenter [6]

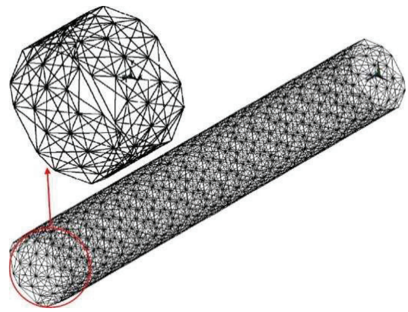

Figure 2: Numerical model of Single Walled CNT indenter

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