Capillary Micromechanics of Cell-encapsulated Microgels

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Cell behaviors, such as adhesion, proliferation, migration and growth, are closely affected by their surrounding environment [1–5]. For example, cells respond to the elasticity of their substrate by changing their stiffness and morphologies [6–12]; stem cell proliferates into different cell types depending on the material properties of substrates including wettability, surface chemistry and elasticity [5,13–15]. Thus, the cell-material interaction is of great importance in understanding the cell responses to signals within their immediate environments [1,2].

Due to its tunable elasticity, microgel is frequently employed to mimic tissues or as synthetic substrates to study cell behavior such as adhesion [9]. Microgels are also extensively used as delivery vehicles in vivo [21], or as scaffolds for 3-D cell culture [22]. For these applications, the interaction between the soft hydrogel materials and cells dictate the fate of delivery vehicles or the cultured cells [21,22].

Among the physical and chemical properties of cell/material interfaces, the mechanics between cell and materials receive wide attention [5–9,15,22,24]. It is shown that kidney epithelial and 3T3 fibroblastic cells can feel and respond to the elasticity of substrates by changes in their reduced spreading and increased motility [8]. Other parameters such as cell type and shape also have more pronounced effect on cell stiffness [6]. These correlations enrich our understanding the interaction between cell behavior and the mechanical properties of their adhesive substrates. However, most of the results are obtained in substrates of 2-D geometry while neglecting the possible influence from fluids in the surroundings [25], which is present in most biological systems. Recent advance of microfluidics enables the encapsulation of cells in 3-D microgels with well-defined physiochemical properties. Moreover, a recently developed technique Capillary Micromechanics allows the comprehensive characterization of mechanical properties of microgels at single particle level [26,27]. Thus, Capillary Micromechanics is promising platform to investigate cell response in well-defined microgels with surrounding shearing flow.

In this work, we encapsulate single cell in a hydrogel microparticle with different stiffness. By using Capillary Micromechanics, we monitor the subsequent development of the cells and correlate their development with the stiffness of the hydrogel matrices. Moreover, the cell proliferation in response to different pressure exerted by surrounding fluids, which is present in vivo, is also investigated. We

demonstrate our approach can be used for studying cell growth in well-controlled environment systematically. Our understandings can provide important guideline when designing hydrogel carriers for biological materials, such as cells and embryos.

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