4bx Low Temperature Polymer Nanofabrication Using Carbon Dioxide and Its Applications to Tissue Engineering

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Biologically benign processing techniques that meet strict design constraints (non-contaminating, non-deforming, low temperature) are necessary for evolving polymer-based MEMS (MicroElectroMechanical Systems)/NEMS (NanoElectroMechanical Systems), especially for systems containing biomolecules and cells. By applying low pressure carbon dioxide (CO_2), we are able to manipulate polymer chain mobility at the nanoscale far below the bulk glass transition temperature of polymers. Atomic force microscopy and neutron reflectivity studies reveal a pressure-tunable width of the surface rubbery layer. Guided by this phenomenon, we successfully demonstrate low temperature fusion of polymeric nanostructures with small compressive force. This biologically benign technique has been utilized to assemble three-dimensional micro/nanoscale polymeric devices for biomedical applications including micro/nanofluidic chips and tissue engineering scaffolds. Tissue engineering aims at reconstructing tissues and organs that have complex architectures and are composed of multiple cells with functions. It is challenging to localize the cells at a specific site, regulate cell behavior, and guide formation and development of new tissues in a controllable manner. Based on the low temperature fusion technique using CO_2, we present a simple, versatile approach of constructing complex tissues. Different types of cells are first cultured in polymeric scaffolds. These scaffolds, with the preloaded cells, are then fused using CO_2. Eventually the construct can be developed into a complex tissue or organ. CO2 could diffuse into the media and fuse the scaffolds with cells grown in it, while the cells (e.g. NIH 3T3 fibroblasts, mouse embryonic stem (ES) cells and human mesenchymal stem cells) kept their viability, growth, and functions. For example, after saturated with CO_2 at 37^{o}C and 200 psi for 1.5 hours, poly(lactide-co-glycolide) scaffolds with different microstructures were fused and the mouse ES cells grown in them were viable, kept their proliferation ability, formed embryonic bodies, and showed the potential to differentiate into multiple cell lineages. This demonstrates that a complex tissue with localized cell types could be constructed.