Effects of Addition of Transition Metal Oxides to Polymer on Growth of Human Cells

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Statement of Purpose: Biomaterials are to replace and/or repair damaged tissue or organs. The most two common biomaterials are metals and polymers. Each of these two materials has its own strength and weakness. For example, metals offer good mechanical strength but lack flexibility. Some metals (such as titanium) form passive oxide layers, therefore have good biocompatibility [1]; they are usually used in medical devices such as bone implants. In the meantime, many polymers are flexible and therefore, useful in soft tissue applications (such as skin grafts, vascular grafts). However, in some cases, it is desirable to have a material that shares the properties of both (for example, good biocompatibility of metals to improve attachment of tissue to polymeric medical devices). Transition metals (such as Ta, Zr, Ti, etc.) are known to form oxide layer upon exposure to the air. The biocompatibilities of their oxides have been studied for promoting new bone growth (for orthopedic applications). However, creating hybrid material of these oxides and polymers remain largely unexplored. The objective of this study is to investigate the effects of adding these transition metal oxides to polymers on growth of human cells. The results of this research have potential applications in modifying polymers to obtain various bioactive properties.

Methods: A rapid screening method was employed in this study to evaluate cellular response on polymers hybridized with different (amount and type) of transition metal oxides. The hybrid materials were prepared as coatings on the well bottoms of tissue culture plates using wet chemistry, metal-organic route. Human cells were cultured on the coated wells (with uncoated wells used as controls) and cell growth was determined using Calcein AM (which retains in living cells and become fluorescent) and fluorescence microplate a reader.

Results:
The results from this study showed that adding transition metal oxides to polymers influenced the growth of human cells (Figure 1). Specifically, primary osteoblast cell density (indicated by fluorescence intensity) after 2 days of culture was the function of weight percentage of zirconium oxide in the hybrid. Compared to polymer only (i.e., without addition of metal oxide), all hybrids had significantly higher cell densities.

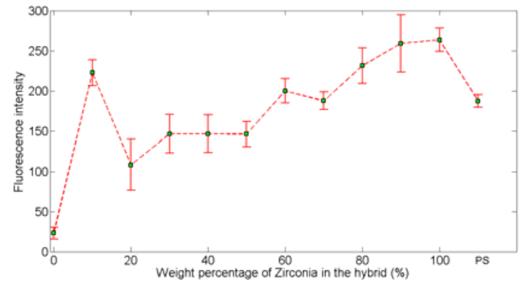

Figure 1. Growth of primary osteoblast was affected by the amount of zirconium oxide in the hybrid. Fluorescence intensity, a measure of living cell density, was measured using a microplate reader with excitation wave length of 494nm and emission wavelength of 517nm.

Cell spreading was also influenced by transition metal oxides (Figure 2).

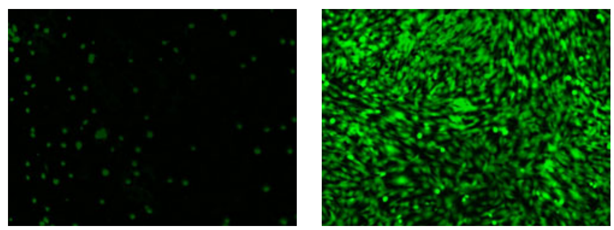

Figure 2. Cell spreading was increased on the hybrid material (right) compared to polymer only (i.e., without metal oxide) (left). Cells were stained with Calcein AM and imaged with 10X objective.

Conclusions: The results from this study showed that hybridizing transition metal oxides with polymers affected the growth of human primary osteoblast cells. Cell spreading and migration were also influenced by the hybridization. These hybrid materials should therefore be further studied for various biomedical applications.

References:
[1]. Ova LJ, Müllera FA, Helebrantb A, Strnadc J and Greila P. Biomimetic apatite formation on chemically treated titanium. Biomaterials, Volume 25, Issues 7-8, March-April 2004, Pages 1187-1194.