Suitability of metal-polymer composites for biomedical applications

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The need for implant materials for bone replacement has been increasing at a fast pace. Keeping this in mind, the main goal of this work was to develop craniomaxillofacial implants for patient-specific implants (PSI) applications with a minimal stress shielding effect, a significant problem for metallic implants such as Ti. For this purpose, two approaches have been taken: a. combinations of sheet-like metal-polymer-metal sandwich materials (SMs); b. reinforcement of the polymers via metal meshes. These composites provide several benefits for biomedical applications, such as tuneable mechanical properties and great acoustic and thermal insulation properties.

Ti was used as skin material to make biocompatible SMs, along with PMMA as core material. For a biocompatible bonding between them, the “grafting from” process was applied to graft PMMA on Ti surfaces. This grafted PMMA was used as an adhesive to achieve satisfactory bonding between the Ti and PMMA. The bonding was attained via fusion bonding. In the study, these SMs showed significantly better thermal and vibrational properties than those of Ti. These SMs also showed the possibility to be used for PSI applications, as in various investigations (bending, deep drawing) they were able to be shaped in desired dimension.

On the other side, the influence of the orientation and vol% of Ti-mesh on the mechanical properties of the Ti-mesh reinforced PMMA composites was investigated. The composites were prepared by adding Ti-mesh between PMMA layers. Hot-pressing above the glass transition temperature of PMMA was used to prepare these composites, where the interdiffusion of PMMA through the spaces in Ti-mesh provided the adhesion between the layers. The increase in vol% of Ti-mesh led to a tremendous improvement in the mechanical properties of composites. A significant anisotropic behaviour was also seen for these composites, where the mechanical behaviour was dependent on Ti-mesh’s direction. The shaping possibility of these composites was also investigated, where the provision of heat made shaping quite feasible for these materials.

These promising results showed the potential of both of these materials to be used for patient specific implants applications.