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Cartilage Mimicking Coatings to Increase the Life-Span of Bearing Surfaces in Joint Prosthesis

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Abstract : Aseptic loosening remains as the principal cause of revision in total hip arthroplasty (THA). For long-term implantations, submicron particles are generated in vivo due to the inherent wear of the prosthesis. When this occurs, macrophages undergo phagocytosis and secretion of bone resorptive cytokines inducing osteolysis, hence loosening of the implanted prosthesis. Therefore, new technologies are required to reduce the wear of the bearing materials and hence increase the life-span of the prosthesis. Our strategy focuses on surface modification of the bearing materials with a hydrophilic coating based on cross-linked water-soluble (meth)acrylic monomers to improve their tribological behavior. These coatings are biocompatible, with high swelling capacity and antifouling properties, mimicking the properties of natural cartilage, i.e. wear resistance with a permanent hydrated layer that prevents prosthesis damage. Cartilage mimicking based coatings may be also used to protect medical device surfaces from damage and scratches that will compromise their integrity and hence their safety. However, there are only a few reports on the mechanical and tribological characteristics of this type of coatings. Clear beneficial advantages of this coating have been demonstrated in different conditions and different materials, such as Ultra-high molecular weight polyethylene (UHMWPE), Polyethylene (XLPE), Carbon-fiber-reinforced polyetheretherketone (CFR-PEEK), cobalt-chromium (CoCr), Stainless steel, Zirconia Toughened Alumina (ZTA) and Alumina. Using routine tribological experiments, the wear for UHMWPE substrate was decreased by 75% against alumina, ZTA and stainless steel. For PEEK-CFR substrate coated, the amount of material lost against ZTA and CrCo was at least 40% lower. Experiments on hip simulator allowed coated ZTA femoral heads and coated UHMWPE cups to be validated with a decrease of 80% of loss material. Further experiments on hip simulator adding abrasive particles (1 micron sized alumina particles) during 3 million cycles, on a total of 6 million, demonstrated a decreased of around 55% of wear compared to uncoated UHMWPE and uncoated XLPE. In conclusion, CIDETEC's hydrogel coating technology is versatile and can be adapted to protect a large range of surfaces, even in abrasive conditions.

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