Fabrication of Ti/Al_2O_3 gradient coating layer using electrophoretic deposition for implant abutment application

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With increasing demand for orthopedic implant, various researches, such as surface treatment, new dental materials, and etc. are being actively pursued.

Orthopedic implant system is composed of fixture, abutment and crown. Among the implant system, titanium alloy is generally used for abutment, but the dark color in titanium causes metal shadow which can be seen through the gums. So development of implant to improve its aesthetics is crucial. To solve its aesthetic problem, Ti/Al_2O_3 gradient coating layer for abutment materials was fabricated using electrophoretic deposition.

The importance of gradual transition with compound is to minimize the residual stress when joining two dissimilar materials, such as metal/ceramic, metal/polymer, ceramic/polymer and etc. Through gradient joining, interfacial coherence can be increased by continuous gradation in composition rather than having a sharp discontinuity. This related research is mainly focused on structure materials, energy storage, thin film and light structure materials and bio-material applications.

A range of fabrication processes have been suggested for gradient coating, namely, physical vapor deposition (PVD), chemical vapor deposition (CVD), plasma or thermal spraying and electrophoretic deposition (EPD).

Among them, EPD is a colloidal processing method involving the motion of charged particles in a suspension under electric field, to deposit particles by coagulation on the electrode. EPD is getting an increasing attention as an effective technique for the processing of bio-materials, especially bioactive coatings and biomedical structures. The well-known advantages of EPD for a wide range of microstructures and complex materials combinations, are being exploited. Moreover, EPD can be easily coated for complex objects.

In this study, EPD has been used to fabricate Ti/Al_2O_3 gradient coating layer on a plate and cylindrical type electrode. $TiAl_3$ or Ti_3Al reaction layer was induced to improve adhesion between Ti and Al_2O_3 during sintering process.

Electrophoretic mobility was measured using zeta-potential analyzer to determine optimal pH range for deposition. After deposition, pressureless sintering with controlling sintering profile was conducted to form a compound at interface between Ti and Al_2O_3. X-ray diffraction (XRD) verified formation of $TiAl_3$ or Ti_3Al. Moreover, these samples were characterized using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The compositional gradients were observed using electron probe microanalyzer (EPMA).

Finally, adhesion test and transparency analysis were done to compare with that of commercial abutment properties. Therefore, Ti/Al_2O_3 coating layers were successfully formed using EPD.