In-situ deposition of graphene oxide by atmospheric plasma for biological applications

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The surface property of the biomaterials affects the interfacial reactions with biological systems and can be improved by physical and chemical surface treatment [1,2]. Graphene is a new class of nanocarbon that has been attracted much attention due to its biomedical applications for drug delivery and regenerative bioengineering. Therefore titanium-based biomaterials are surface treated to enhance cell-material interaction by direct deposition of graphene oxide (GO) and reduced graphene oxide (rGO) with various surface properties, i.e., hydrophobic, superhydrophobic, and hydrophilic. A novel method is used for the synthesis of rGO and GO using high dense atmospheric plasma deposition under atmospheric pressure at room temperature in the absence of a catalyst. The transition from hydrophobic to superhydrophobic and hydrophilic is achieved with additional heat treatment and argon plasma treatment. These various surface coatings are applied to the biological application, establishing their relationship and effect on cell viability.
Furthermore, the surface with micro/nanopores is developed on the titanium implant by the nitriding process, followed by GO deposition to promote osseointegration and prevent peri-implantitis. GO deposited on the Ti surface assessed in the antibacterial effect of Porphyromonas gingivalis (P. gingivalis) and streptococcus (S. mutans). Biocompatibility is evaluated by MTT assay to demonstrate cytotoxicity and Alizarin Red S staining to compare cell differentiation. The adhesion of S. mutans and P. gingivalis was evaluated by Crystal Violet Assay. The adhesion, proliferation degree of Mouse osteoblastic cell line MC3T3-E1 cell was evaluated by WST-8 Assay. Morphology of the deposited coating is analyzed through Raman spectroscopy, X-ray photoelectron spectroscopy (XPS), and field-emission transmission electron microscopy (FE-TEM). XPS analyses revealed different oxygen-containing functional groups that make the surface hydrophilic, resulted in superior biocompatibility in comparison with other surfaces and bare titanium. In vitro test, MTT assay, and Alizarin Red S staining, the graphene oxide layer did not show cytotoxicity but enhancing osteoblast cell differentiation and fibroblast cell growth. The Ti surface with micro/nanopores and the graphene oxide coating reduced the adhesion of S. mutans, forming an initial biofilm, and P. gingivalis, which induces the peri-implantitis. The novel functionalized surface and graphene oxide coating could be an alternative implant surface treatment to prevent peri-implantitis and promote osseointegration.

References

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Figures

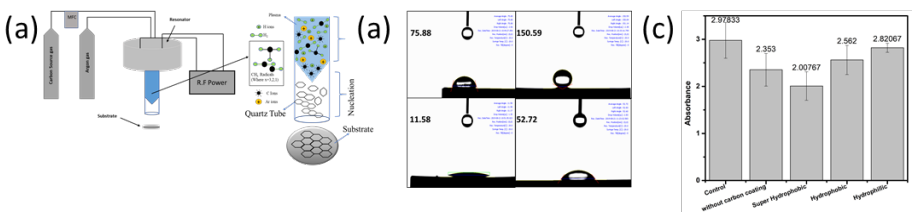

Figure 1: (a) Schematic of GO synthesis (b) Contact angle measurement on various surface conditions (c) MTT assay result of various surface conditions.