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## ORIGINAL PAPER

# Characterisation of hydroxyapatite surface modified by poly(ethylene glycol) and poly(hydroxyethyl methacrylate) grafting

**Katarzyna Adamska, Magdalena Szubert, Adam Voelkel, Zuzanna Okulus***

*Institute of Chemical Technology and Engineering, Poznań University of Technology, Pl. M. Skłodowskiej-Curie 2, 60-965 Poznań, Poland*

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Hydroxyapatite (HA) has many applications in medicine as a biocompatible and bioactive biomaterial. Numerous studies have shown that modification of the HA surface can improve its biological and chemical properties. However, little is known about the surface properties of modified materials. In this paper the influence of organic polymers: polyethylene glycol (PEG) and polyhydroxyethyl methacrylate (pHEMA) on the surface properties and surface chemistry of hydroxyapatite (HA) is presented. The surface properties of modified HA were characterised by the FT-IR, XPS, BET, and zeta potential measurements. Specific surface area was determined by BET. Infrared and XPS spectra confirmed the presence of PEG and pHEMA on the surface of HA. The BET $N_2$ adsorption revealed slight changes in the HA surface chemistry after grafting modification. The surface chemical properties of the HA were considered to be based on the zeta potential. The decrease in zeta potential results in the increasing stability of the modified material and also in the reduction of bacterial adhesion. The reaction for surface modification of HA is proposed and described.


**Keywords:** hydroxyapatite, surface modification, polyethylene glycol, infrared spectroscopy, X-ray photoelectron spectroscopy

## Introduction

Hydroxyapatite (HA) – the material with chemical formula $Ca_{10}(PO_4)_6(OH)_2$ belongs to the apatite group. It is a bioceramic material resorbable in human tissue (Park & Bronzino, 2003). The Ca/P molar ratio in this compound is equal to 1.67 (Park & Bronzino, 2003; Shi, 2004).

Hydroxyapatite, due to its biological properties and structural similarity to human bones and teeth, has many applications in medicine as a biomaterial, especially in: orthopaedics, dentistry, maxillofacial, and plastic surgery (Arakaki et al., 1995; Liu et al., 1998a). HA is also applied as a drug carrier (Shinto et al., 1992), adsorbent in protein column chromatography (Liu et al., 1998b; Tanaka et al., 1998), catalyst (Tanaka et al., 1998; Siddharthan et al., 2005), and ion exchanger (Siddharthan et al., 2005). The most important attributes of HA are its biological properties, such as high biocompatibility and bioactivity (Shi, 2004; Arakaki et al., 1995; Shinto et al., 1992). HA exhibits a positive impact on the wound-healing process (Arakaki et al., 1995) and as a bioactive material promotes the growth of new bone (Arakaki et al., 1995; Siddharthan et al., 2005). This property is known as osteoconductivity – this means that hydroxyapatite acts as a kind of “scaffold” for new bone cells.

However, it was found that HA is resorbed too slowly in comparison with the speed of new cells restoration (Shi, 2004; Hong et al., 2004). Slow resorbability limits the application of HA in modern medicine as an individual biomaterial. Hence, modification of the HA surface is required. Polyethylene glycol (PEG) and poly (2-hydroxyethyl methacrylate) (pHEMA) can be considered as suitable materials for surface modification of HA. PEG is a non-toxic, biodegradable material with a high degree of biocom-

*Corresponding author, e-mail: zuzanna.okulus@o2.pl