PREPARATION POSSIBILITIES AND FTIR SPECTROSCOPY OF UHMWPE-ALGINATE BLENDS

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ABSTRACT

Continuing our research on UHMWPE (Ultra-High- Molecular-Weight Polyethylene) based implant material and its fusion with Ca-alginate in this paper we describe. We describe new methods for preparing Ca-alginate coated UHMWPE samples and how we extended the testing of the prepared samples. If sufficient coating with Ca-alginate can be achieved and the Calcium providing layer can be made on UHMWPE, it might lead to an implant material which can promote bone formation. Earlier result shows that the Calcium–alginate layer can be formed on the UHMWPE. Using our new modified methods we can make polyethylene samples with sufficiently tough alginate layer which can withstand washing and sterilization as shown in the paper.

INTRODUCTION

Previous research was carried out based on the work of Jian-Ping Wang, Xing-Xiang-Zhang, Xue-Chen Wang [1]. As we had earlier experience with UHMWPE implant materials, by modifying the surface properties of it using acrylate type monomers. Thereby enhancing its wear resistance, it was an interest of us to evaluate if further surface modifying would improve the biocompatibility of the prosthetic material [2]. We realized quite early that the same method of bulk surface modification, which worked well with materials like methyl-methacrylate monomer (MMA) [3,4], would not yield a useful surface with the hydrophilic alginate material. This prompted us to work with powder type UHMWPE. We made basic experiments with GUR 4210 UHMWE powder to form an alginate layer which could trap calcium from calcium-salt solutions; we also have determined the optimal sequence of the treatments, and the necessity of etching the UHMWPE powder [5].

For the majority of our experiments described here we used GUR 1020 UHMWE powder, and two different modification methods were carried out, to form insoluble alginate layers. After preparation of the samples, morphological examinations, Ca\textsuperscript{2+} ion extraction tests and wear tests were carried out [6,7,8].

METHODS AND MATERIALS

The used UHMWPE is GUR 1020 (Average molecular weight: 4×10^6 g/mol (Mw)) powder. Two different methods were used in order to form the calcinated alginate layer. First method: In the first step the sodium alginate's (ISP Alginites) aqueous solution (1 wt% solution) then the calcium chloride (2 wt% aqueous solution) was sprayed onto the polymer powder.

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Second method: In the first step the sodium alginate (ISP Alginates) solution (1 wt% aqueous solution) then the calcium sulfate (2 wt% aqueous solution) was sprayed onto the polymer powder. This order of steps is considered the “direct” order. The methods were repeated also in reverse order. First, the treatment with the Ca-salt solution then the alginate spray coating.

MEASUREMENTS

We made FTIR measurements to check the alginate content on the surface of the blends.

FTIR (Bruker Tensor 27) tests were carried out to answer if the surface of the treated UHMWPE powder holds the alginate, and if it is found in different forms. From the results of the tests, we were able to choose the most optimal method for binding Ca on the surface of the UHMWPE powder. If after the pressing and irradiation, the FTIR curves show the alginate absorption peaks, it also means that the calcium alginate is present on the polymer which was our intent, however sodium alginate is water-soluble but calcium alginate is not.

![FTIR spectra on pressed UHMWPE alginate blend sheets](image)

**Figure 1.** FTIR spectra on pressed UHMWPE alginate blend sheets (Black – GUR1020; Magenta – GUR1020-CaSO₄-alginated blend, Red – GUR1020-CaCl₂-alginated blend)

After pressing the alginated powder samples into sheets, FTIR measurements were carried out to check the alginate’s presence in the blends. For those samples, for which we used CaSO₄ treatment, the peaks at 1080 and 1050 cm⁻¹ wave number in the spectra were much higher than of the ones for we used CaCl₂ treatment (Fig.1.).

We also checked the presence of the alginate components after the irradiation. After the irradiation the samples show less alginate content but it is still present on the surface of the blends (Fig.2.). Both on CaCl₂- or CaSO₄-alginated UHMWPE blends, the FTIR spectra shows alginate peaks between 1750 and 750 cm⁻¹ wave numbers (Fig.3.).

In the samples prepared by “direct” order alginate Ca-treatment the spectra showed higher alginate content.
Figure 2. FTIR spectra on pressed and irradiated UHMWPE CaCl$_2$-alginate blend sheets (Black – GUR1020; Red – GUR1020-CaCl$_2$-alginate blend, Gold – GUR1020-CaCl$_2$-alginate blend after irradiation treatment)

Figure 3. FTIR spectra on irradiated UHMWPE alginate blend sheets after irradiation treatment (Red – GUR1020; Blue – GUR1020-CaCl$_2$-alginate blend, Dark blue – GUR1020-CaSO$_4$-alginate blend)
SUMMARY

The treatments which we tried out proved to be suitable for fixating calcium(II) ions on UHMWPE polymer surfaces. The polymer powder is capable of binding with the surface of the sodium alginate and is able to hold the created calcium alginate during processing and after the 20 kGy irradiation process. The radiation did not affect the behavior and properties of the alginate salts. The presence of calcium alginate on the surface was proved with great confidence using FTIR measurements. The wear tests and the extraction experiments are still in progress.

Our experiments were carried out on GUR 1020 UHMWPE powder. We would also like to carry out these tests on production UHMWPE hip joint cups too, to check that the alginate is able to adhere to the surface of a processed hip joint cup.

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REFERENCES


