SELENIUM – ENRICHED BRUSHITE: A PROMISING MATERIAL FOR POTENTIAL USE IN BONE IMPAIRMENTS TREATMENT

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Introduction

Bioactive and biocompatible, calcium phosphates (CaP) are widely applied biomaterials in bone tissue and dental surgery, serving as bone fillers, coating materials and drug delivery system matrices [1]. One of them, dicalcium phosphate dihydrate (DCPD), described with the formula $CaHPO_4 \cdot 2H_2O$ (known as a mineral brushite) exhibits relatively high solubility [2] and is considered to be an intermediate phase in the processes of bone mineralization and enamel dissolution.

The solubility of potential bone-substituting materials has an impact on the regeneration of mineralized tissue and the release rate of therapeutic agents, i.e., foreign ions or drugs possibly introduced into the crystal lattice of CaP. Introducing foreign ions is one of the potential ways to improve the biomaterial's properties. For instance, silicon may enhance its bioactivity, silver can provide it antibacterial activity, while selenium usually serves as internal anticancer agent [3-4].

Apart from taking part in oxidative stress protection, affecting positively the immune system and being essential for bone turnover, selenium, as it was mentioned above, exhibits an anticancer activity. Among different selenium species, selenites (SeO_3^{2-}) revealed the most significant effectiveness of this kind [5].

To the best of our knowledge, there have been no published studies on DCPD containing selenium. Due to this and the reasons mentioned above, in this work, Se-doped brushite was synthesized using a standard, wet method and then physicochemically examined.

Materials and Methods

Both samples of pure brushite (Bru) and selenium-doped brushite (Se-Bru) were prepared using a wet precipitation method. To obtain selenium-modified brushite (Se-Bru) the reagents: $Ca(NO_3)_2 \cdot 4H_2O$, $(NH_4)_2HPO_4$ and Na_2SeO_3 were weighed out so that the molar ratio of Ca/P+Se was close to 1.0 and then dissolved in distilled water. The water solutions of phosphate and selenite were instilled into the calcium solution. The precipitation process was carried under permanent stirring. Once adjusting the pH to about 6, the stirring was continued for one hour. Afterwards, the precipitate was left for 24-hour aging and subsequently filtered and washed out with distilled water. Finally, the precipitate was dried at a temperature of 90ºC for 24 h. The route of the synthesis of pure brushite (Bru) was technically the same. The only difference was that there was no selenium source among the reagents, which were weighed out so that the Ca/P ratio was ca. 1.0.

The dried powders were homogenized in mortar and characterized using following methods: SEM microscopy, PXRD, FT-IR, ssNMR and ICP-MS.

Results and Discussion

The SEM microphotographs (FIGs. 1A and 1B) proved that the investigated samples differed significantly in morphology. The elongated and plate - like shaped, crystals of pure Bru (FIG. 1A) possessed a diameter and length of about 10 and 20-30 μm, respectively. In turn, Se-Bru sample exhibited a rod-like morphology (FIG. 1B) with the crystals of the diameter of 5-7 μm and length above 25 μm. Unlike Se-Bru crystals, Bru ones were strongly agglomerated.

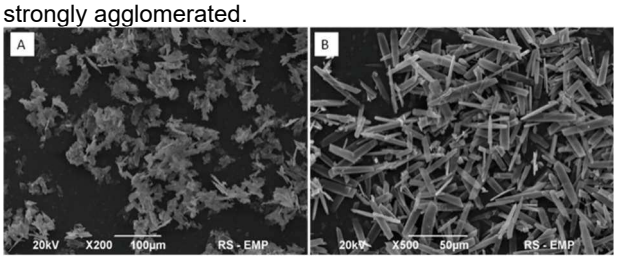

FIG. 1. SEM images of Bru (A) and Se-Bru (B).

Analysing the diffractograms of both samples, all of the reflections were assigned to the brushite monoclinic structure (JCPDS 09-0077). No impurities were detected. A visible reduction of the relative intensity of (020) and (040) reflections of the Se-Bru sample was observed. In the Se-Bru diffractograms, the reflections mentioned above exhibited a slight difference in position, which indicates that introducing selenite affected the crystallinity and crystal morphology of the sample [6]. Furthermore, the significant increase of the *a* parameter accompanied by the simultaneous decrease of the *c* parameter in the Se-Bru sample proves that selenite ions were incorporated into the crystal structure (TABLE 1) [7].

TABLE 1. Various samples' parameters determined from the PXRD diffractograms.

Parameters	Bru	Se-Bru
Phase composition	**100 % DCPD**	**100 % DCPD**
Unit cell parameters		
***a* (Å)**	**5.915**	**6.238**
***b* (Å)**	**15.12**	**15.16**
***c* (Å)**	**6.242**	**5.806**
***β* (˚)**	**116.4**	**116.4**
Volume ((Å)^3)	**500.2**	**491.7**

The selenium content in the Se-Bru sample was measured using the ICP-MS method. The concentration of Se was equal to 0.67 ± 0.03 wt%.

Conclusions

In the present study, DCPD containing 0.67 wt% of selenium was synthesized. Future investigations concerning selenium release and *in vitro* studies on its biological properties are in progress and will contribute to the full evaluation of obtained material.

Acknowledgments

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