Bioactivity of Hydroxyapatite/Montmorillonite Clay Nanocomposite

Rosnah Nawang[a*], Mohd Zobir Hussein[a], Khamirul Amin Matori[a,b], Che Azurahanim Che Abdullah, Mansor Hashim[a], Rosiah Osman[a]

[a]*Institute of Advanced Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
[b]*Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
**Corresponding Autor's Email: rnawang@upm.edu.my*

Abstract: I*n-vitro* bioactivity behavior of hydroxyapatite (HA)/montmorillonite (MMT) nanocomposite was studied by immersing the samples in a phosphate buffer solution. The weight changes before and after the testing were recorded and the morphology of the samples was studied. Results showed that a significant weight loss occured in nanocomposite with the ratio of HA:MMT 50:50. The morphology of the sample revealed the apatite formation on the surface of the nanocomposite which suggested the potential use of the material for bone implant application.

Keywords**:** hydroxyapatite, montmorillonite, bioactivity, phosphate buffer solution.

INTRODUCTION

Bioactive materials are the materials that can form chemical bonds with bone tissue. The bone tissue will be connected to the implant material through this chemical bonding process[1] and the formation of bone-like apatite will be occurred on its surface when it is implanted in a living body[2]. The bioactivity of a materials can be studied either by *in vivo* or *in vitro* testing. In vivo testing involves the using of animal model, which is expensive and needs specialists in laboratory animals, placing of the implants, and sacrifice of the animals for collecting samples. On the other hand, i*n vitro* testing can be studied either by using simulated body fluid (SBF) or using osteoblasts cell culture, which are more practical and not time consuming[3]. Simulated body fluid (SBF) was first developed by Kokubo[2] to mimic human body fluid. In this test, the sample will be immersed in the solution for a variable period of time and the chemical changes on the surface of the sample were analyzed. Besides SBF, Hank's solution[4] and phosphate buffer solution (PBS)[5] were also used to study the bone-bonding capacity of bioactive materials. It was reported that silicate-based bioceramics could give an excellent forming apatite ability when immersed in SBF[6], however, phosphate and sulphate-based bioceramics did not give a good forming apatite ability in SBF[7], even though it had shown a great performance in *in vivo* testing. Thus, SBF has been suitable for study the apatite formation ability for silicate-based bioceramics, but not for phosphate and sulphate-based bioceramics. In this work, the sample was HA-based ceramic, therefore, PBS was used to study the apatite forming ability during the bioactivity test. Furthermore, PBS is easier to prepare, compared to SBF and Hank's solution.

MATERIALS AND METHODS

Hydroxyapatite was purchased from Acros Organic and montmorillonite KSF (MMT) clay was obtained from Aldrich. The nanocomposites were prepared by mixing HA powders with MMT in the ratios of HA:MMT of 90:10 and 50:50 (wt%) on a rolling mill at 50 rpm for 26 hrs. The mixed powders were then pressed into a cylindrical shape (6 x 6) mm. The samples were then sintered at 800 ˚C for 2 h in an electrical furnace.

RESULTS AND DISCUSSION

Fig. 1 shows the XRD pattern of the samples sintered at 800 ˚C. Sintered HA showed the presence of HA and whilockite phases, whereas sintered MMT showed the presence of muscovite, MMT and quartz phases. It can be observed that the addition of 10% MMT (nanocomposite 90:10) did not change the phases formed in the sintered sample but it reduced the crystallinity of the resulting nanocomposite. On the other hand, the addition of 50% MMT clay (nanocomposite 50:50) enhanced the formation of whitlockite phase and contributed to the formation of anhydrite ($CaSO_4$) phase. The existence of anhydrite phases gave a positive outcome which could enhance the bioactivity of the nanocomposites.

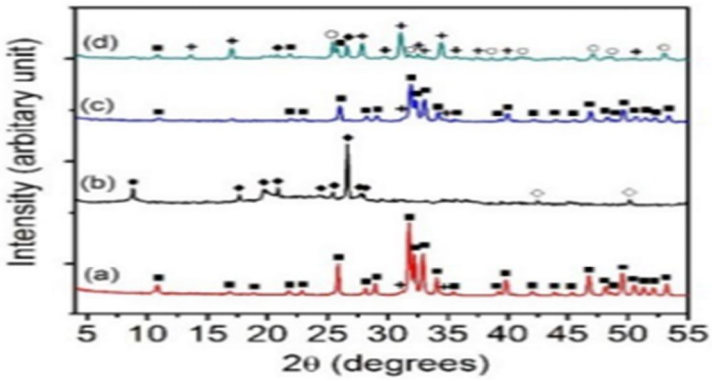

Fig. 1. XRD patterns of sintered (a) HA, (b)MMT, (c) 90-10, (d) 50-50. HA (■), MMT (◆), quartz (◇), muscovite (●), whitlockite (✚), anhydrite (○)

CONCLUSIONS

PBS solution can be used to study the bioactivity of hydroxyapatite/montmorillonite nanocomposites. The results indicate that the addition of MMT clay can enhance the bioactivity of the nanocomposite through the existence of anhydrite phase.

REFERENCES

[1] Dos Santos, V.; Brandalise, Rosmary Nichele; Savaris, M. Biomaterials: Characteristics and Properties; 2017.
[2] Kokubo, T.; Takadama, H. *Biomaterials* 2006, ***27***, 2907–2915.
[3] Renno, A. C. M.; Bossini, P. S.; Crovace, M. C.; Rodrigues, A. C. M.; Zanotto, E. D.; Parizotto, N. A.; Lu, R. W. *Biomed Res. Int.* 2013, **5**, 1–7.
[4] Suzuki, H.; Yagi, R.; Waki, T.; Wada, T.; Ohkubo, C.; Hayakawa, T. *J. Oral Tissue Engin* 2016, ***14*** (1), 9–14.
[5] Shamsul Baharin Jamaludin; Maizatul Shima Nur; Derman, M. N. *Acta Metall. Slovaca* 2014, ***20*** (1), 82–88.
[6] Hench, L. L. *J. Am. Ceram. Soc.* 1991, ***74*** (7), 1487–1510.
[7] Liu, G.; Zhao, L.; Cui, L.; Liu, W.; Cao, Y. *Biomed. Mater.* 2007, ***2***, 78–86.
[8] Hughes, E. A. B.; Grover, L. M. *Biomater. Res.* 2017, ***21*** (1), 7.
[9] Klimchouk, A. *Int. J. Speleol.* 1996, ***25*** (3–4), 21–36.