Iran Polym J (2017) 26:313–322
DOI 10.1007/s13726-017-0521-5

ORIGINAL PAPER

Synthesis of polyvinyl alcohol hydrogel grafted by modified Fe_3O_4 nanoparticles: characterization and doxorubicin delivery studies

Mojtaba Abasian[1] · Vahid Hooshangi[1] · Peyman Najafi Moghadam[2]

Received: 12 December 2016 / Accepted: 13 March 2017 / Published online: 24 March 2017

Abstract During the last two decades, serious efforts have been directed towards the synthesis and coating magnetic nanoparticles for biomedical applications. Among many different types of polymeric coating materials that have been utilized in previous studies, we have selected polyvinyl alcohol (PVA). In this study, we report a novel type of magnetite nanocomposite-based PVA hydrogel. For this purpose, first, Fe_3O_4 nanoparticles were modified through hexamethylene diisocyanate (HMDI) and then PVA was modified by bromoacetyl bromide to produce bromoacetylated PVA. The modified PVA was cross-linked through various diamines such as ethylene-diamine, propylene-diamine and hexamethylenediamine. The prepared weak tridimensional PVA hydrogels were further reacted through unreacted hydroxyl groups with Fe_3O_4, modified by HMDI to form magnetite hard tridimensional hydrogels. The swelling behavior of the prepared magnetite nanocomposites were investigated and showed a fast initial swelling followed by a mild increase until attaining equilibrium. The structural, morphological, thermal and magnetic properties of the synthesized magnetite nanocomposites were confirmed by FTIR, thermal gravimetric analysis, vibrating sample magnetometer and scanning electron microscopy. The doxorubicin anti-tumor drug was loaded on a selected synthesized magnetic hydrogel and in vitro drug release studies were done in phosphate buffer solution in 37 °C.

✉ Mojtaba Abasian
m_abbasian@pnu.ac.ir; m_abbasian20@yahoo.com

1 Department of Chemistry, Payame Noor University, P.O. Box: 19395-3697, Tehran, Iran

2 Department of Organic Chemistry, Faculty of Chemistry, Urmia University, Urmia, Iran

Keywords Hydrogel · Polyvinyl alcohol · Magnetite · Nanocomposite · Doxorubicin · Drug delivery

Introduction

Magnetic nanoparticles (MNPs) have attracted much attention [1–3] in biomedical and industrial applications due to their biocompatibility, facility of surface modification and magnetic properties [4–6]. Although there have been many significant developments in the synthesis of magnetic nanoparticles, maintaining the stability of these particles for a long time without agglomeration or precipitation is an important issue [7]. Moreover, the common MNPs have high chemical activity, and are easily oxidized in air (especially magnetite). Without any surface adjustment, the MNPs have a large surface-in-volume ratio and, therefore, possess high surface energies, consequently, they tend to aggregate [7, 8]. To overcome aggregation and provide high colloidal stability, usual coating of the MNPs has been noted to be considerable [9, 10]. Coating can be achieved through polymeric materials such as dextran, polyethylene glycol (PEG), polyvinyl alcohol (PVA), chitosan, and starch [11–13]. Moreover, some inorganic materials such as gold and silica have been used for coating purposes [14, 15]. Organic compounds coated on MNPs offer a high potential application in several areas. The structure of organic compounds functionalized on the MNPs preserved the magnetic property of MNPs as well as the other properties of organic molecules [16–18]. Since a protective shell does not only serve to protect the magnetic nanoparticles against degradation [19], it can also be used for further functionalization with specific components, such as catalytically active species, various drugs, specific binding