Journal of Molecular Liquids 393 (2024) 123631

Contents lists available at ScienceDirect

Journal of Molecular Liquids

journal homepage: www.elsevier.com/locate/molliq

Optimization of carboxymethyl cellulose-gum Arab-based hydrogel beads for anticancer drugs delivery

Abdullah A. Ghawanmeh [a], Ling Ling Tan [b], Gomaa A.M. Ali [c,d], Mohammed A. Assiri [e], Kwok Feng Chong [f,g,*]

[a] Department of Pharmaceutical Technology and Cosmetics, Faculty of Pharmacy, Middle East University, Amman, Jordan
[b] Southeast Asia Disaster Prevention Research Initiative (SEADPRI), Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia, UKM 43600 Bangi, Selangor Darul Ehsan, Malaysia
[c] Chemistry Department, Faculty of Science, Al–Azhar University, Assiut 71524, Egypt
[d] Faculty of Advanced Basic Science, Galala University, 43511, Suez, Egypt
[e] Department of Chemistry, Faculty of Science, King Khalid University, Abha 61413, P.O. Box 9004, Saudi Arabia
[f] Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Gambang, 26300 Kuantan, Malaysia
[g] Center for Advanced Intelligent Materials, Universiti Malaysia Pahang Al-Sultan Abdullah, 26300 Kuantan, Pahang, Malaysia

ARTICLE INFO

Keywords:
Response surface methodology
Carboxymethyl cellulose
Gum Arab
Biopolymer
Hydrogel beads
Drug delivery system

ABSTRACT

Response surface methodology was successfully utilized to optimize the amounts of carboxymethyl cellulose (CMC) and gum Arab (GA) to fabricate hydrogel beads for the delivery of anticancer drugs. Drug encapsulation efficiency process (%DEE) and cumulative release (%R_{8h}) of hydrogel beads were investigated with different amounts of CMC and GA with Fe (III) cross-linker. The numerical validation resulted in an optimized nanocomposite of CMC (99.61 mg) and GA (77.84 mg) with a DEE of 55.70 ± 2.15 % and R_{8h} of 44.78 ± 0.27 %. The characterization approaches indicated the successful formation of this nanocomposite. The swelling behavior of the beads was triggered by pH change, and the drug release profile showed prolonged sustainable release that followed the Higuchi model with a non-Fickian mechanism. This nanocomposite could be a promising nanocarrier for drug loading and its controlled delivery.

1. Introduction

The drug nanocarriers with a stimulus-responsive character is important in medical investigation, due to their drug controllable-release rate, enhanced therapeutic effectiveness and increased safety for cancer therapy [1–4]. For anticancer drug delivery, stimulus-responsive hydrogel is a perfect nanocarrier choice in terms of biocompatibility, biodegradability, non-toxicity, high water uptake, and strong mechanical properties. Specifically, these properties arise from the polymeric structures that form the three-dimensional (3D) nanocomposite matrix through a physical or chemical cross-linker [5,6]. These hydrogels could be prepared through various techniques, such as the ionotropic gelation technique [7–9], which has several advantages over conventional solution techniques, including reduction of organic solvents usage, dose frequency reduction, and enhanced therapeutic efficiency [8,10].

Natural polymer-based stimuli response hydrogel earns more consideration than a synthetic ones, most porbably due to the drug-controlled manners in various environmental conditions, such as temperature and pH [11–15]. For example, alginate and carboxymethyl cellulose have been utilized in the drug delivery approach [16–18]. Nevertheless, some drawbacks result from such natural delivery systems, including weak mechanical properties and drug bursting during delivery, which cause rapid degradation and uncontrollable release. Moreover, using chemical cross-linkers may add a toxic issue to the matrix system, which unfavorably affects the drug release process

Abbreviations: 5-FU, 5-Fluorouracil; CMC, carboxymethyl cellulose; GA, Gum Arab; FTIR, Fourier-transform infrared; XRD, X-ray diffraction; SEM, Scanning electron microscopy; CCD, Central composite design; DI, Deionized water; RSM, Response surface methodology; OFAT, One factor at a time; DEE, Drug encapsulation efficiency; DoE, Design of Expert; ANOVA, Analysis of Variance; HGB, Hydrogel beads; UV–Vis, Ultraviolet–visible; R_{8h}, Drug release after 8h; R^2, The coefficient of correlation; ICH, International conference on harmonization; HG-O, Hydrogel beads – optimized.

* Corresponding author.
E-mail address: ckfeng@ump.edu.my (K.F. Chong).

https://doi.org/10.1016/j.molliq.2023.123631
Received 17 February 2023; Received in revised form 15 November 2023; Accepted 17 November 2023
Available online 23 November 2023