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ORIGINAL ARTICLE

Development of amine-functionalized superparamagnetic iron oxide nanoparticles anchored graphene nanosheets as a possible theranostic agent in cancer metastasis

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Abstract

The major objective of the present investigation was to assess the targeting potential of a designed system for breast cancer at metastatic phases with imaging ability. In a nutshell, we have developed surface-engineered graphene oxide (GO) nanosheets by covalent linking with amine-functionalized iron oxide nanoparticles (IONPs) (GOIOIs). Gefitinib (Gf) was selected as a model drug and entrapped in between exfoliated GO sheets (GOIGF) via π-π* stacking before functionalization with IONPs. Preliminary characterization of GO, IONPs, GOIOI, and GOIGF was performed using UV-visible and Fourier transform infrared spectroscopy. Scanning and transmission electron microscopy studies confirmed successful surface engineering of GO with IONPs. The in vitro drug release study demonstrated sustained release of Gf. The magnetic behavior of IONPs and GOIOI demonstrated a sigmoidal-shaped hysteresis loop with superparamagnetic properties. The in vitro cell cytotoxicity assay was carried out on MDA-MB-231 breast cancer adenocarcinoma cell lines. The cell cytotoxicity assay showed 61.18% inhibition of cell growth with 30 ppm concentration containing 64% of the drug, whereas 100% of the pure drug revealed only 56% of inhibition. In the near future, GOIOI could be tailored further for theranostic research, especially for metastatic cancers.

Keywords Carbodiimide chemistry · Gefitinib · π-π* stacking · MDA-MB-231 breast cancer adenocarcinoma cell lines · Magnetic graphene · Drug delivery

Introduction

Cancer is the most devastating disease in human; one out of six deaths is because of cancer, and the estimated death count may increase up to 13.1 million by 2030. It is the major cause of morbidity and mortality at present. In females, breast cancer is the leading site of cancer followed by cancer of the cervix and uteri [1].

Chemotherapy [2], gene therapy [3], radiotherapy [4], surgery [5], photodynamic [6], photothermal therapy [7], hyperthermia [8], or a combination thereof have been used for the treatment of cancer. Unfortunately, no effective therapy could successfully eradicate cancer to date. Theranostic nanomedicine is the latest approach under investigation, which could systemically provide simultaneous diagnosis and treatment at a specific site of infection. This could avoid interaction with normal cells, and only cancer tumor cells get destroyed using suitable carrier molecules [9]. The survival rate in cancer patients was dismal from 5 to 15% from developing to developed countries, respectively. Mutation of cancer cell specifically in the epidermal growth factor can be characterized to identify 50% of adenocarcinomas [10].

With the emergence of 2D materials, graphene has gained attention for its use in various biomedical applications including cancer. Graphene is an allotrope of carbon in the form of a single layer of atoms in a two-dimensional hexagonal lattice in which one atom forms each vertex [11, 12]. There are numerous methods available for the synthesis of graphene oxide (GO), an oxidized counterpart of graphene such as mechanical

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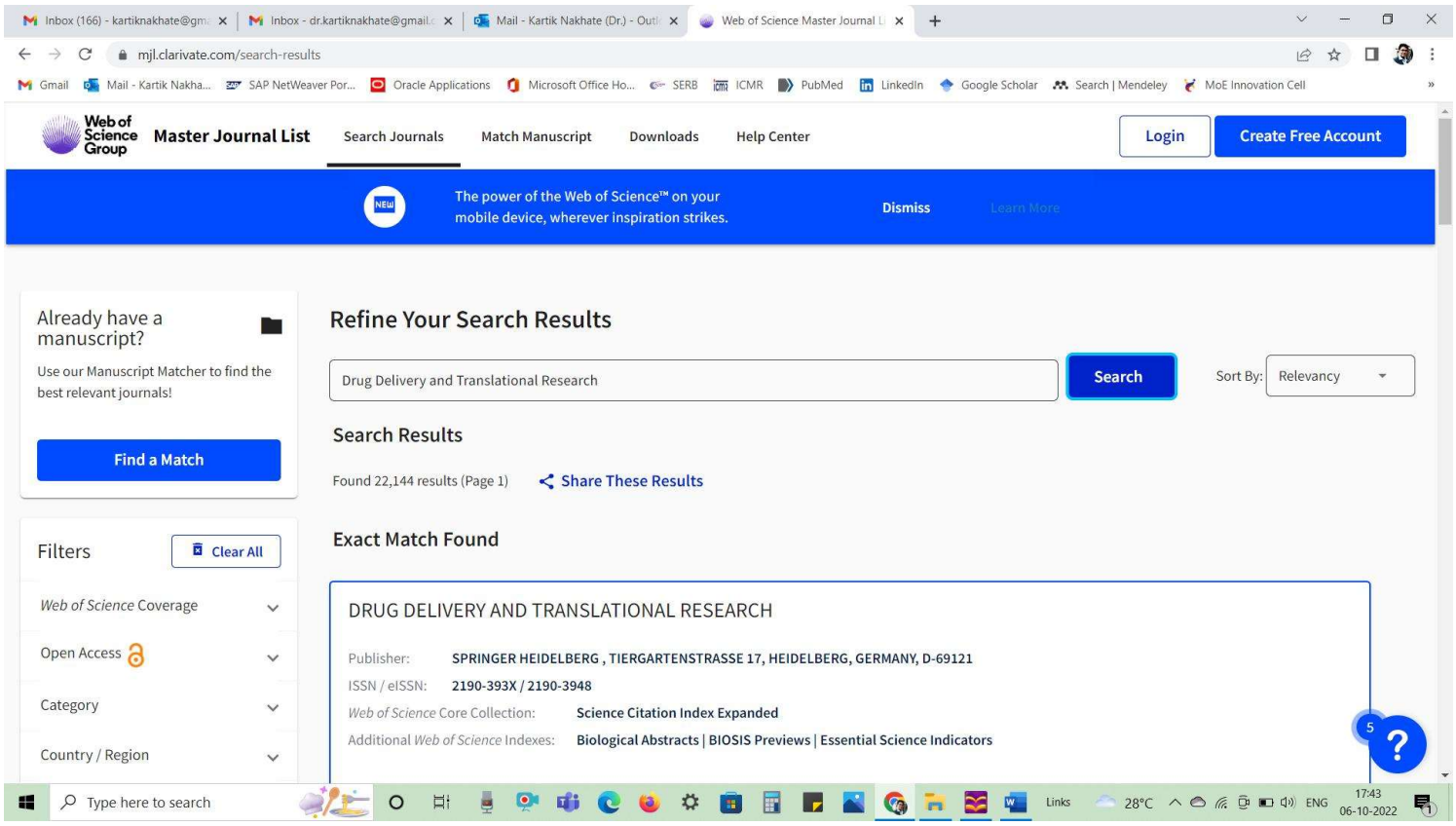
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