Cairo University

Mechanical Properties of Electrospun Cellulose Acetate/Graphene Oxide Composite Nanofibers and Its Effectiveness For Removing Organic Dyes

By

Eng. Nada Mohamed Ibrahim Abd-Elmotaleb

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
MECHANICAL DESIGN AND PRODUCTION ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

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Key Words:

Graphene Oxide; Cellulose Acetate; Composite nanofibers; Mechanical properties; Electrospinning

Summary:

The thesis main objectives were studying mechanical properties of Graphene Oxide (GO) incorporated Cellulose Acetate (CA) composite nanofibers prepared via electrospinning technique and producing highly efficient photocatalyst based on composite nanofibers Graphene Oxide (GO), Cellulose Acetate (CA), and surface functionalized TiO_2-NH_2 nanoparticles was developed.

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Finally, I wish to acknowledge and express my deep gratitude to all those who helped me in presenting this work.

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Abbreviations

CA	Cellulose Acetate
NCCA	Nanocrystalline Cellulose Acetate
GO	Graphene Oxide
RGO	Reduced Graphene Oxide
TiO_2	Titanium Dioxide
CNT	Carbon Nanotube
MWNT	Multi Walled Nanotube
ZnO	Zinc Oxide
Fe_2O_3	Ferric Oxide
CdS	Cadmium Sulfide
ZnS	Zinc Sulfide
NH_2	Amino Group
NPs	Nanoparticles
IC	Indigo Carmine
MB	Methylene Blue
TTIP	Titanium Isopropoxide
TEOTi	Titanium Ethoxide
TBT	Titanium Butoxide
APTES	3Aminopropyltriethoxysilane

$HO^{\bullet}$	Hydroxyl Radicals
NaOH	Sodium Hydroxide
HCI	Hydrochloric Acid
VB	Valence Band
CB	Conduction Band
P	Phenol
GA	Glutaraldehyde
DMF	N, N-Dimethylformamide
SEM	Scanning Electron Microscope
XRD	X-ray Diffraction
TGA	Thermo Gravimetric Analysis
FTIR	Fourier Transform Infrared Spectroscopy
PH	Hydrogen Ion Concentration

Dedication

I sincerely dedicate this work to my parents…

Abstract

Nanotechnology is a multidisciplinary field that including nanofiber materials which fabricated at the nano scale. Nanofiber materials have superior applications and lead to functions with higher order structures. Electrospinning is the most versatile process that producing nanofibers material with a diameters ranging from nano to sub-micron. The electrospun nanofibers can be reinforced by particles to fabricate composite nanofibers with unique and good properties. Furthermore, the photocatalytic process has a greet attentions due to dye wastewater treat due to its effectiveness, easy operation, lower cost, non-selective degradation and high efficiency. An attempt was made in this thesis unique CA-GO/TiO_2-NH_2 system was fabricated by chemical crosslinked between electrospun composite nanofibers and TiO_2-NH_2 nanoparticles.

The first part of this work was co-electrospun Graphene Oxide (GO) with Cellulose Acetate (CA) for the production of fluorescence nanofibers composite. The weight percentage of GO varied from 0.05 to 1.5 wt. % in the polymer solution. The morphologies and crystal structures of the resultant composite nanofibers were investigated by scanning electron microscopy (SEM) and X-ray diffraction (XRD). The specific interaction was demonstrated by (FT-IR). It was resulted that with increasing GO content the nanofibers diameters decreasing as a result of decreasing the value of the flow rate to generate continuous ultrafine fibers, which ranges from 300±90 for pure CA nanofibers to 210±90 for 1.5 wt.% CA/GO.

The tensile test was performed in order to measure the mechanical properties of pure CA nanofibers and CA/GO composite nanofibers with GO contents of (0.05, 0.5, 1 and1.5 wt.%). It is concluded that with increasing GO contents the tensile strength, and Young's modulus was improved. The composite nanofibers with 1.5 wt.% GO content shows high tensile strength, which improved about 73% than the pure CA nanofibers 49 MPa. In addition, the highest Young's modulus of CA/1.5%wt GO composite nanofibers was 1600 MPa, which improved by 75% than the pure CA nanofibers 400 MPa. The improvement in tensile strength and Young's modulus indicated to a good dispersion of GO in the CA polymer and strong adhesions between their surfaces. It is significant from the obtained values from the tensile test that the addition of GO improves the mechanical properties of CA nanofibers.

The second part was focused on study the photocatalytic performance of the composite nanofibers for the degradation of two model molecules, methylene blue, and indigo carmine. The photocatalytic degradation was investigated under UV light irradiation. In this regard, an effective photocatalyst obtained from composite nanofibers CA/GO fabricated by electrospinning technique followed by chemical crosslinking surface modified TiO_2 nanoparticles (NPs) which was used for removing the organic dyes of indigo carmine (IC) and methylene blue (MB) from the aqueous solution under UV light irradiation. The crystalline structure analysis and morphologies of CA-GO/TiO_2-NH_2 composite nanofibers were characterized by SEM, TEM, XRD, TGA and FTIR. The prepared CA-GO/TiO_2-NH_2 composite nanofibers displayed significantly enhanced photocatalytic activity for photodegradation of the organic dyes IC and MB under UV light irradiation after 150 min and 250 min respectively. The pH

value of the solution was studied from 2-8 which showed a clear improvement of photocatalytic activity at pH 2. The results indicated that the activated CA-GO/TiO_2-NH_2 composite nanofibers employed as an adsorbent for the removal of IC and MB from the aqueous solutions. In addition, the results showed a high adsorption capacity remain up to 65% after five consecutive capacity cycles.