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Study on the Activity of Ag/Nylon 6, 10 Nanocomposite Against *Escherichia coli*

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Silver nanoparticles was synthesized by reduction method and used for loading nylon 6,10 to form Ag/nylon 6,10 nanocomposite.The nanocomposite was characterized by X-ray fluorescence (XRF). The antibacterial activity was performed against *Escherichia coli* and the effective antibacterial activity observed for Ag/nylon nanocomposite at different concentration of silver nitrate.

Introduction

Polymers nanomaterials are more interested in the design daily life requirements due to their safety and friendly with the environment (Crespy and Landfester, 2007). Recently, the new type of polymer nanocomposites has been reported with high improved properties over neat polymers (Zhang *et al*., 2003; Leuteriz *et al*., 2003). Nylon was the first commercially successful synthetic polymer, consist of segments of polyethylene $(CH_2)n$ separated by peptide units (NH-CO) which are parallel or ant-parallel:

Nylon-n:-[-(NH-CO)-(-CH2)n-]- (1)
Nylon-m,n:-[-(NH-CO)-(CH2)n-2-(CO-NH)-(CH2)m-]- (2)

The unit of the peptide was provided hydrogen bonding between polymer chains giving nylon some of its unique properties (Dasgupta *et al*., 1996). Nylon is a polar synthetic polyamide can be prepared from adipoyl chloride and hexamethylene diamine to form a linear nylon 6,10. It is particular nylon is made of units of 6 carbons between two nitrogen atoms, an amide linkage, another unit of 10 carbons (Beecroft and Ober, 1997). Metal nanoparticles have several applications in the various areas such as catalysis (Ying *et al*., 1999), magnetic (Morey *et al*., 2000), biomedical materials (Kong and Jang, 2008) and optoelectronic (Liu et al., 1998; Schneider *et al*., 2000). The metal/polymer nanoparticles have the

potential advantage due to their size particles and distribution of dispersed of metal nanoparticles can be controlled depending on the properties of the host polymer (Zhang *et al*., 1999; Shi *et al*., 2011). However, metal nanoparticles often have the tendency to aggregate in the polymer matrix during nanofiber formation. Hence, a facility and feasible approach to attain good dispersion of nanoparticles in the polymer nanofiber matrix is highly desirable (Park *at al*., 2009). The Controlling shape of nanoparticles is important for chemical, physical, thermal, optical, electric, magnetic and catalytic properties of nanoparticles (Xia *et al*., 2003; Wu *et al*., 2001; Murphy, 2002; El-Sayed, 2001; Maier *et al*., 2003) and dispersion of nanoparticles has an effect on the properties of nanoparticles composition (Cai *et al*., 2010). Therefore, the Tadros (Tadros, 1993) divided the dispersion of ultrafine particles in medium into: (i) Wetting of particles in dispersion medium. (ii). The breaking of aggregations into mono-dispersing particles or smaller aggregations. (iii) Stabilization of mono-dispersing particles and smaller aggregations against re-agglomeration. During the past decades, silver nanocrystals, such as nanoparticles, nanorods, nanotubes, and nanowires, have received much attention due to their different physical and chemical properties in comparison to bulk silver (Huang *et al*., 2015). In this paper, we prepared nylon 6,10 by interfacial synthesis technique from 1,6 hexamethylene diamine with Sebacyl chloride as shown in Figure 1, then loaded with different concentration of silver nitrate to form Ag/nylon nanocomposite and their activity studied against *E. coli* bacteria.

Materials and Methods

1,6 hexamethylene diamine, Sebacyl chloride, silver nitrate (AgNO3) and sodium borohydride (NaBH4) were provided by Koya University. All Chemicals were used without further purification. Distilled water was used for all the synthesis and measurements.

Synthesis of Nylon 6,10

Nylon 6,10 was synthesized by interfacial synthesis technique. In addition 20ml of 0.5 weight percent of sebacoyl chloride in cyclohexane to 20ml of 0.5 weight percent 1,6-hexanediamine in water. The polymer was collected from the interface of the two-phase.

Synthesis of Ag-loaded Nylon 6, 10

The fabricated nylon 6,10 put in distilled water for 48h to remove all interference and solvent. Then, the swollen nylon was put in an aqueous solution of the different concentration of silver nitrate (0.5mM, 1.5mM, 2mM) in the present of 0.5 mM sodium borohydride for 24hours at 30 ^{0}C until the different dark color of nylon 6.10 nanoparticles which was indicated the formation of Ag nanoparticles within the nylon 6,10 network.

The constant weight was gained by washing the fabric with distilled water for 10 second and dried in the oven at 45^{0} C for 12hours.

Antibacterial Performance

The antimicrobial assay of a sample was performed by disc diffusion method as described by Kirby-Bauer. Loop full growths from bacterial isolate were inoculated into nutrient broth incubated at 37°C for 18 hours. The bacterial suspensions were diluted with normal saline. Adjust the turbidity and compare with standard tube (McFarland number 0.5) to yield a uniform suspension. A cotton swab was dipped and

streaks into adjustment suspension the entire Mueller-Hinton agar. Sample pleats or discs were gently pressed on the surface of the agar. The plates were incubated overnight at 37°C while the antibiotic diffuses from the disc into the agar. After incubation, the plates were examined for the presence of inhibition zones.

Results and Discussion

XRF is an effective method of analyzing silver metals, thin films and nylon polymers. The polymers (nylon) samples were placed in the chamber and measured by 20 mm diaphragm in the vacuum. X-ray spectra were obtained using RX9, Cu, Mo and Al conditions. In these analyses, the X-ray tube current was set to approximately 1 mA for the RX9 target and into 0.5 mA for other targets. The X-ray tube voltage has been set to 25 kV only for the RX9 and 50 kV for Cu, Mo and Al targets. The X-ray measuring time was only 200 s for the Al target and 100 s for other targets. Silver metals were higher energy (22 Kev) and appear in Al targets.

Figure 2 shows the X-ray spectra for polymer and fabric. When the detector absorbs fluorescence, its proportion conductance was a change in the energy of the fluorescence which is processed by the electronic. The signal of fluorescent on horizontal axis was measured in kilo-electron volts and the intensity occurrence per second on the vertical axis. The energy of the fluorescent has identified the elements during the measurements. Figure 2a shows the only strong intensity of peak for nylon 6,10 and the strong intensity of peaks of silver nanoparticles can be observed at different concentration in fabricating samples as shown in Figure 2b, 2c, and 2d which are indicated the formation of Ag/nylon 6,10 nanocomposite

Figure.1 Synthesis of Nylon-6,10 Fibers

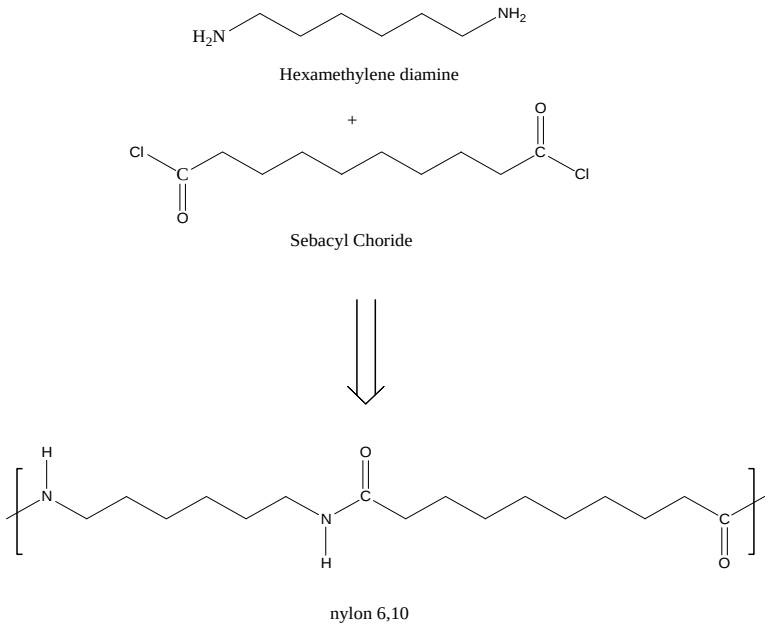


Figure.2 X-ray Spectra for Nylon a) Nylon without Ag b) Nylon with 2mM $AgNO_3$ c) Nylon with 1mM $AgNO_3$ d) Nylon with 0.5 mM $AgNO_3$

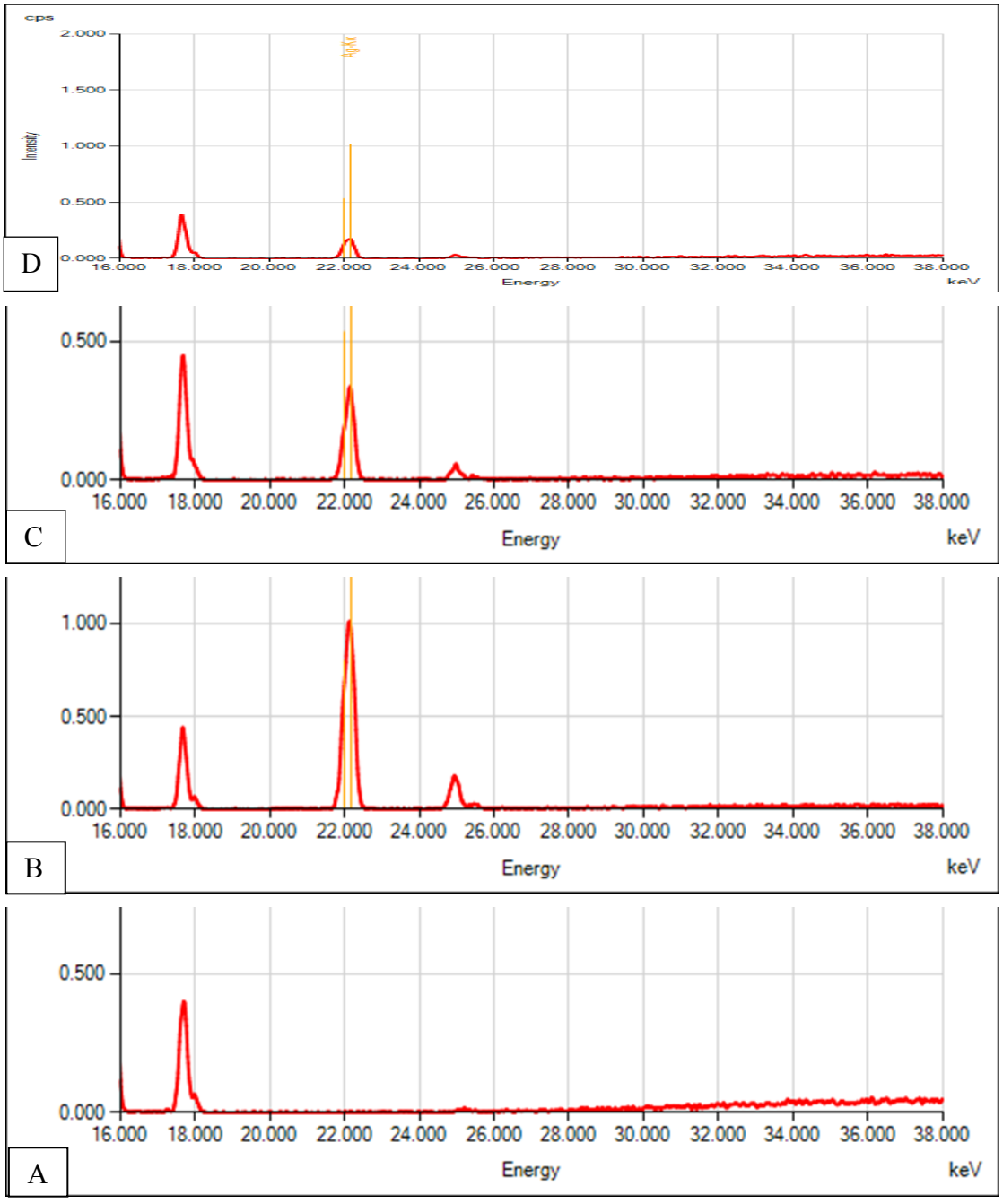
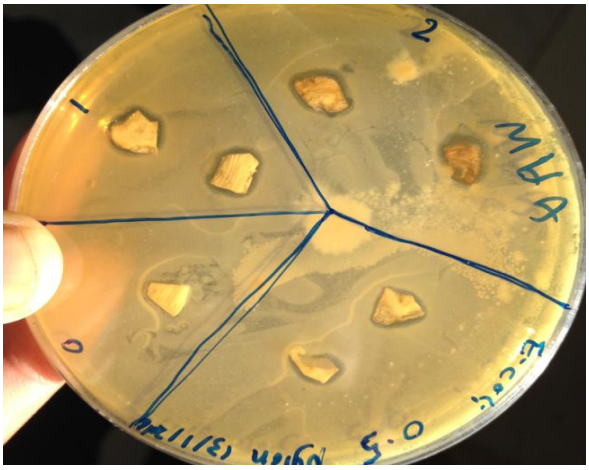


Figure.3 Antibacterial Activity of Ag/nylon 6,6 Nanocomposite against *E. coli* a) Nylon without Ag b) Nylon with 2mM $AgNO_3$ c) Nylon with 1mM $AgNO_3$ d) Nylon with 0.5 mM $AgNO_3$



Antibacterial Activity of Ag/nylon 6,10 Nanocomposite against *E. coli*

The antibacterial activity of the fabric was tested against E. coli bacteria. For qualitative measurement of antibacterial activity, the Ag-loaded fabric was cut into 6-8mm diam. Discs and tested using the modified agar diffusion assay (disc test). The plates were examined for possible clear zones after incubation at the 30°C for 3 hours. The presence of a clear zone around the circular disc on the plate medium was recorded as an inhibition against the microbial species as shown in Figure 3. The nylon 6,10 without loading does not have activity against *E. coli*, but when loaded with different concentration of silver shows activity against *E. coli* and the antibacterial activity of fabric depends on the concentration of Ag used for loading nylon 6, 10.

In conclusion, The Ag/nylon 6,10 nanocomposite successfully synthesized by reduction method and sodium borohydriate was used as reducing agent. The synthesized Ag/nylon 6, 10 nanocomposite was characterized by XRF for indicating a formation of the nanocomposite. The nylon 6,10 and the fabric at different concentration of silver was tested against the *E. coli*. The effectiveness of fabric as antibacterial observed against *E. coli* bacteria.

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