The Effect of Nylon 6.6 Nanofiber Layers on Mechanical Properties of Epoxy

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---**ABSTRACT**---
In this study mechanical properties of epoxy resin reinforced with different numbers of nanofiber layers of nylon 6.6 which produced with electrospinning method was investigated. Solution of 10 wt % of Nylon 6.6/ formic acid was used for electrospinning. The special molds were prepared to produce the laminated composite plates. Static tensile tests were performed, and the specimens were evaluated with respect to tensile strength and elongation at break, which are aspects of their basic mechanical properties.
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I. INTRODUCTION

The epoxy resins have been widely used as adhesives and matrices of insulation material of superconducting magnets, due to their good electrical insulation properties, advantageous heat and chemical resistance, high elastic modulus, low density, strong bond ability, and convenient manufacturing process [1–3]. To reach the desired mechanical and thermal properties, one approach is the addition of micro- or nanofillers such as nanofibers or nano particles to a polymer [4,5]. When the diameters of polymer fiber materials are shrunk from micrometers to nanometers, there appear several amazing characteristics such as flexibility in surface functionalities, very large surface area to volume ratio, and superior mechanical performance compared with any other known form of the material [6]. The present work investigates the use of an electrospun polymeric nanofibrous layers to enhance composite laminate mechanical performances. Nylon 6.6 electrospun nanofiber layers are fabricated by electrospinning and placed in an epoxy matrix. Different layer numbers (5, 10 and 15 layers) were used to reinforce the epoxy. After the tensile test the tensile load- displacement results were evaluated.

II. EXPERIMENTAL

Nylon 6.6 was purchased from Sigma–Aldrich company. Nylon 6.6 granules was dissolved at 10 wt% in formic acid (Fig. 1). The solution was stirred at room temperature and stirred with ultrasonic bath to ensure its dissolution.

| (a) | (b) |

Fig. 1. Solution preparation (a) Nylon 6.6 granules, (b) Solution

Electrospinning were carried out on a horizontal setup as shown in Fig. 2. A syringe was used as injector. The electrospinning setup consisted of a syringe, a syringe pump, a grounded electrode connected with rotating drum, and a high voltage power supply which could generate positive DC voltages up to 50 kV. The value of electrospinning parameters were chosen as follows: voltage 30 kV, distance between the tip of the spinneret and

collector 20 cm, solution feed rate 0.3 mL/h. Electrospinning was performed at room temperature and the syringe set up was enclosed in a chamber. The discharged jet undergoes a whipping action that further elongates the polymer, and the repulsive electrostatic field splits the jet into fine submicron fibers that were collected on a grounded metal collector or drum. The polymer fiber diameter and its alignment depends on the type and concentration of polymer in the solution, applied voltage, flow rate, needle diameter, distance between needle and collector drum, and the type of collector.

Fig. 2. Electrospinning setup

For one sheet nylon 6.6 layer 10 mL solution was used. Fig. 3 shows the layer at the end of spinning.

Fig. 3. Naylon 6.6 nanofiber layer

The specimens were cut in accordance with ASTM D638-10 as shown in Fig. 4.

Fig. 4. Specimens cut

A special mold was designed and manufactured to produce laminated composites (Fig. 5). The MGS L160 was used as a resin and H160 as a hardener. After wetting the layers they placed in the mold and cured in room temperature.
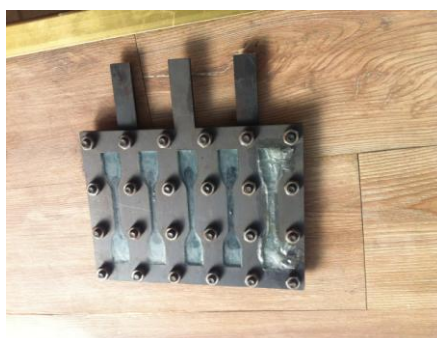
Fig. 5. Specimen preparation

Fig. 6 shows the specimens reinforced with 5, 10 and 15 nanofiber layers of nylon 6.6 after the manufacturing process.


Fig. 6. Nylon 6.6 reinforced specimens

Table 1 shows weight percent of nylon 6.6 layers in epoxy composites.

Table 1. Weight percent of nylon 6.6

| Layer numbers	wt %
5	0.4125
10	1.2069
15	3.1616

III. RESULTS AND DISCUSSION

The obtained results of the tensile tests of epoxy and composites with the reinforcement content of 5, 10 and 15 layers are presented in Fig. 7. The presented values demonstrate the changes in the mechanical behavior of the epoxy under tensile loading.
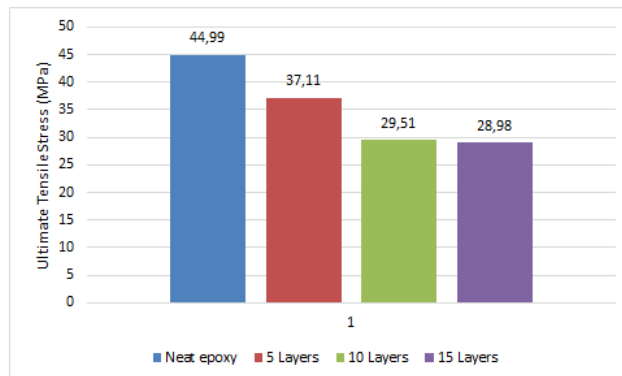
Fig. 7. Ultimate tensile stress

Fig. 8 shows the displacement values at break.
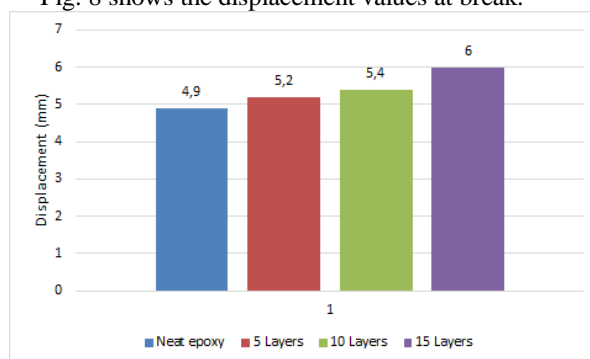
Fig. 8. Displacement at break

It is seen that insert 5 layers in epoxy (0.4125 wt %) decreases the strength 17.52 % and gives 6.12 % elongation compared to neat epoxy. Similarly insert 10 and 15 layers (1.2069 and 3.1616 wt %) decreases the strength 34.41 % and 34.59 % but increases the elongation 10.2 % and 22.44 % respectively.

IV. CONCLUSION

The nanofiber nylon 6.6 layers were produced using electrospinning by dissolving nylon 6.6 granules in formic acid solution. The nylon 6.6 layers were placed in epoxy using special mold. The mechanical properties of neat epoxy, 5 layers, 10 layers and 15 layers nylon 6.6 reinforced composites plates were investigated.

As a result of tensile tests, the tensile stress values decreases and the elongation at break increases by the increasing the layer numbers.

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