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Highly Conductive Nanostructured Composites Based on Multi-Layer Graphene and Polymers for Flexible Heaters

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INTRODUCTION

The demand for flexible heaters, such as body heating devices for thermal comfort and health improvement for poor blood circulation is growing fast in recent years. However, the high cost of these devices nowadays prevents their large-scale use. This work proposes the construction of low-cost flexible expanded graphite films with excellent electrical and thermal properties, together with good mechanical properties and biocompatibility thus allowing for numerous biomedical and cosmetics applications. Here we show preliminary results in development of nanostructured composites based on expanded graphite with polymeric materials, looking for flexible heaters applications.

MATERIALS AND METHODS

Flexible films were prepared by mixing multi-layer graphene platelets with 2 polymer a polyelectrolyte polymer(GPP) and acrylic polymer (GPA) (~10% w/w) and water until formation of a viscous paste. The material was stirred continuously for 10 minutes at room temperature and then spread on a PTFE substrate film using a doctor blade technique. Samples were dried for 4 hours at 90°C and finally were calendered to provide better uniformity, alignment of graphene flakes and reduced porosity of the film material.

RESULTS AND DISCUSSION

Figure I show the sheet obtained (A4 size) and the micrograph image of a film cross-section.

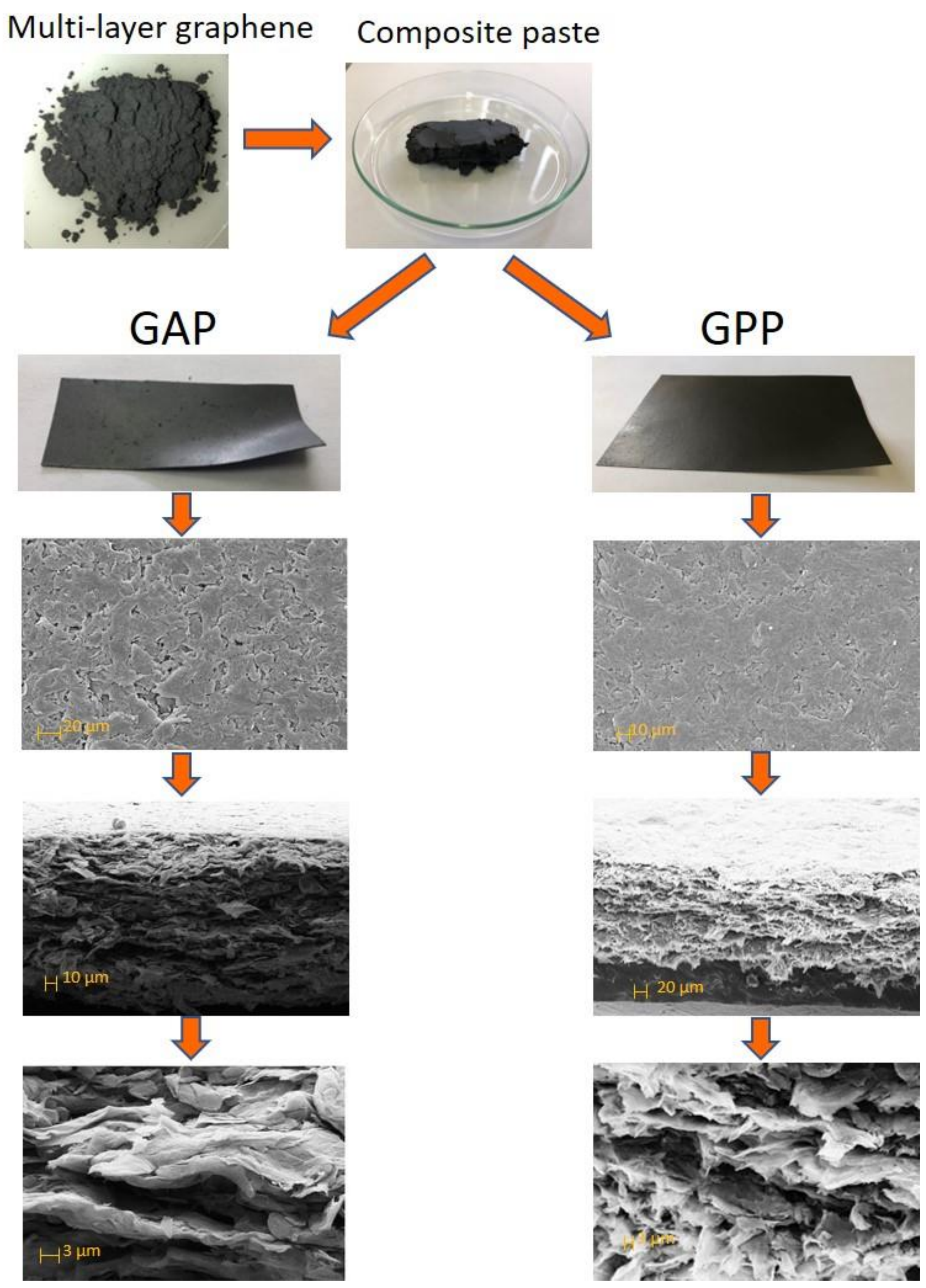

Table I: Electrical and Thermal tests results

Sample	Composition	Thickness (mm)	Resistence (Ω)	Resistivity (Ω.cm)	Thermal Conductivity (W/m.K)
GPP	Graphite, Polyelectrolyte Polymer, water	0,25	0,083	$9,4.\ 10^{-3}$	44,8
GAP	Graphite, Acrilic Polymer, water	0,229	0,1181	$1,2.\ 10^{-2}$	40,5

The results obtained for resistivity (GAP), $1,2.10^{-2}$ Ω.cm are superior compared with those reported in literature for various polymeric composites with carbon nanotubes with best results in the range of 7.10^{-2} Ω.cm, for buckypaper of multi-walled carbon nanotubes with values close to 1.4 Ω.cm and with exfoliated graphite in cellulose solution of 4.10^{-2} Ω.cm. The analysis of results on thermal conductivity of polymer nanocomposites, shows that no significant gain was observed with the use of the polyelectrolyte polymer. The reports in literature show results considerably smaller: 11,2 W/m.K for graphene/epoxy polymer composites and 0,85 W/m.K for paraffin/expanded graphite composite, so the composites prepared here have superior thermal properties.

The tensile tests were performed in according to ASTM D 882-02 Standard, and the results are summarized in Table II.

Table II: Tensile test results

Sample	Mechanical Properties	
	Young modulus (MPa)	Tensile strength (MPa)
GPP	76,6	0,09
GAP	668,1	1,57

Comparing the Young modulus results above for the GPP sample (76,6MPa) and for GAP sample (668,1 MPa), it can be concluded that the structure of the nanocomposite with acrylic polymer is much more resistant than that for that produced with polyelectrolyte polymer. The flexural strength was performed in according to ASTM D 790. The results of the flexural strength of polymer nanocomposites are summarized in Table III.

Table III: Flexural test results

Sample	Mechanical Properties
	Flexural strength (GPa)
GPP	7,247
GPA	9,944

These results show that the sample produced with acrylic polymer (GPA) presents greater resistance to rupture by flexion than that produced with polyelectrolyte polymer (GPP).

CONCLUSION

Results obtained in development of composites based on acrylic polymer and polyelectrolyte polymer, show in general superior mechanical performance for that based on acrylic polymer while electrical properties are comparable. It is important to emphasize high content of multi-layer graphene in the composite (90%) used here as compared with values reported in literature.

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