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Stimulus-responsive and conductive composites for remote sensing applications

Anastasia Elias
University of Alberta, aelias@ualberta.ca

Preetam Anbukarasu
University of Alberta

Dominic Sauvageau
University of Alberta

STIMULUS-RESPONSIVE AND CONDUCTING COMPOSITES FOR REMOTE SENSING APPLICATIONS

Anastasia Elias, Chemical and Materials Engineering, University of Alberta
aelias@ualberta.ca
Preetam Anbukarasu, Chemical and Materials Engineering, University of Alberta
Dominic Sauvageau, Chemical and Materials Engineering, University of Alberta

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Inexpensive and portable sensors are increasingly democratizing data collection and data analysis on both large and small scales. Materials which are both conducting and responsive (able to undergo a change in property in response to a desired stimulus) could form the basis for a variety of sensors. In our work, we are developing these materials for use in radio frequency identification (RFID) tags in which the conducting and responsive material is integrated directly into the antenna of the tag. A change in the dielectric properties of the antenna leads to a measurable change in the remotely-readable properties of the device, including reflected power and peak frequency. By tailoring the responsivity of the material to appropriate analytes, a variety of biosensors can be engineered.

Towards implementing sensors for bacteria and biomolecule detection, we are developing an enzyme-responsive system which undergoes a simple on-to-off transition in the presence of the enzyme. Our composite is comprised of a bio-degradable polymer blended with graphene. The composite is produced using a solution-casting process in which the two materials are dissolved in solvent at an elevated temperature, sonicated, and then deposited onto heated substrates. The graphene imparts the conductive properties to the composite, while the degradable polymer (polyhydroxybutyrate, PHB) undergoes rapid degradation in the presence of the enzyme of interest. The degree of crystallinity of PHB (as determined by x-ray diffraction) was found to be a key determinant of the rate of degradation of the material, and thus of the response time. We have therefore investigated the physical properties of the PHB/graphene composites, and have found that both the degree of crystallinity and electrical conductivity of the composite materials are highly dependent on the casting conditions, particularly temperature (Figure 1). In addition, we have found that the crystallinity of the material increases throughout the first 48 hours of aging at room temperature, after which a plateau is reached. The electrical resistance of the nano-composite followed a similar trend, with longer ageing times resulting in decreased resistance (Figure 1).

In this presentation, both the initial physical properties of graphene-PHB composites, and their degradation behavior in the presence of enzyme solutions will be explored. Integration of these materials into antennas will be described, and stimulus-induced on-to-off transitions in these antennas will be demonstrated.

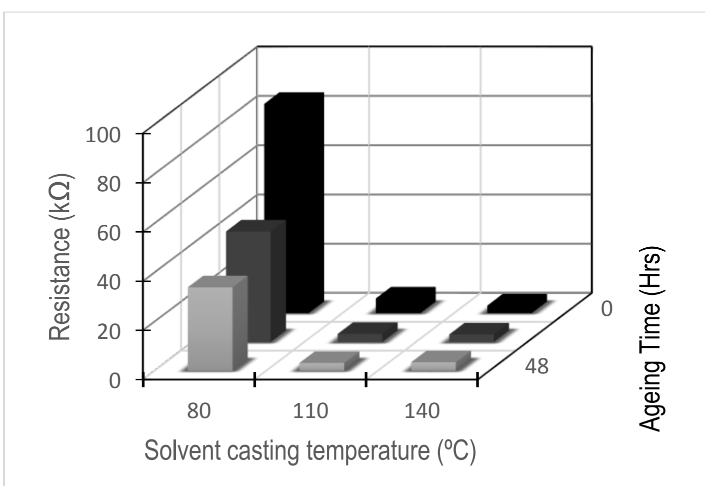

Figure 1 – effect of solvent casting temperature and ageing time on the electrical resistance of PHB/Graphene nanocomposite