Silk Fibroin composites for next generation of sustainable smart materials development

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Materials development supports the growth of new tools to meet social and technological challenges. Among the different materials, plastics are essential, and practically omnipresent because their properties, accessibility, and low cost. Unfortunately, plastics are synthesized from oil, and they tend to accumulate in nature, which represents a serious environmental impact. To minimize these injuries, replacing synthetic polymers (plastics) by bio-based materials is proposed. Unfortunately, the knowledge about these materials and how to modify them is still limited.

To boost the knowledge about bio-based materials and promote their use, the present work has focused on, the development of sustainable materials with advanced properties. In specific, Silk Fibroin (SF), a protein obtained from Bombyx mori (silkworm) cocoons has been selected as primary material. Mainly because its unique properties (such us piezoelectricity, mechanical resistance, and water processability) and accessibility. As a route for pushing the SF properties beyond its current limits, composite materials processing has been explored.

Based on SF potentiality, one main field of application has been selected: active composites for electronics. In this regard, SF has been combined with i) carbon nanotubes (CNT) to obtain force sensors with piezoresistive response (PR) of ~ 4 MPa^{-1} at pressures of 0.11 MPa; ii) with silver nanowires (SNW) to obtain transparent sensors with a PR of 26 GPa^{-1} when the pressure is between 0.2 and 0.4 MPa. A material also capable of producing energy; iii) with cobalt ferrite nanoparticles (CFO) to obtain magnetic actuators with a magnetization value of ~ 10 emu·$g^{-1}$and coercivity of almost 4 kOe, (20 wt. % CFO); iv) with ionic liquids (IL) to obtain bending actuators with bending responses of ~ 0.5 by applying low voltages (3-5 V); and v) finally, with ceramic barium titanate ($BaTiO_3$) nanoparticles, to obtain capacitors with a dielectric constant up to 142 for the SF/$BaTiO_3$ composite with 40 wt %.

The current work is presented as a general overview of different composites development to control the SF properties, and applicability. The developed different demonstrators representing a proof of concept about the bio-based materials and composites potentiality. This work, pretending to be a reference for future research.

References

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Figures

Figure 1: Scheme of SF nanocomposites for smart materials development.