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Sustainable operation of solar panels with improved light harvesting and self-cleaning capabilities integrated in a smart network

Scientific activity report

Stage 1 *16.07.-31.12.2026*

During the first stage of the project implementation, activities were carried out regarding the aquisition of reagents/materials/consumables/equipment required for the associated research directions, scientific documentation regarding the approach of the strategies stated in the project proposal, as well as a series of experimental activities, as follows:

Experimental studies on the preparation of new photoemissive polymeric materials containing carbon nanostructures, polymerization photoinitiators testing, preliminary preparation of film-forming photoluminescent polymeric materials, and adaptation of photoemissive polymeric materials for 3D printing.

The initial approach involves obtaining new copolymers based on salts of styrene-sulfonic acid, acrylic acid, and hydroxyethyl acrylate, respectively. The goal is to configure a rigid polymeric matrix that favors radiative transitions from the triplet state, yielding persistent photoluminescent emission with a phosphorescence lifetime on the order of seconds. The obtained copolymer must exhibit high optical transparency and also to allow embedding of Carbon Dots nanostructures acting as UV-Vis photonic converters. The nanocomposite thus obtained must exhibit high photonic conversion efficiencies, optical transparency, persistent phosphorescence, and appropriate physico-chemical stability of the resulting thin layers. To increase the quantum yield of radiative transitions, carbon nanostructures (CNDs) were dispersed in deuterated mediums compatible with the previously mentioned monomers. A significant increase in the photoluminescent emission intensity and the preservation of their emission in the green region of the visible spectrum were observed. In subsequent stages, a monomer deuteration strategy will be studied and experimentally developed to obtain the aforementioned polymeric matrices with improved physico-chemical characteristics, in particular increasing the rigidity of the polymeric matrix to favor the establishment of triplet excited states in radiative transitions. The dispersion of CNDs in monomers adapted for 3D printing was also experimentally tested.

Study on the selection of monomers/polymers and chemical compounds capable of radiative relaxations from the triplet state.

A series of chemical compounds showing potential for radiative relaxations from the triplet state and monomers enabling the obtention of "host-guest" type polymeric materials were selected. Thus, the chemical configurations of phenothiazine, phenylcarbazole, and aminoacridine, alongside the possibilities of obtaining host-guest polymeric materials, were studied. Another targeted approach is achieving persistent phosphorescence by introducing acetylacetone transition metal-based complexes into polymeric matrices. A series of polymerization photoinitiators were also tested.

Preliminary configuration of the resonant system for self-cleaning PV solar panels. Testing of piezoceramic/electromagnetic transducers, configuration of the control subsystem, preliminary testing of the PV panel-transducer resonant system at various oscillation frequencies.

Tests were performed with piezoceramic/electromagnetic transducers attached to a 20W PV panel model, taking measurements at various operating frequencies of the oscillating system within the ranges of 15–200 Hz and 12–21 kHz, respectively, using various waveforms. The control and amplification system for the transducers was configured. Tests were carried out regarding the positioning of the transducers on the bottom surface of the PV panels to maximize the coupling of the PV panel-transducer oscillating system and improve the oscillation transfer functions.