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Mid-infrared Characterization of Elastomers for Radiative Cooling Applications

Vijayasimha Reddy Ireddy[1,*], *Daniele* Ceneda[1], Marco Centini and *Maria Cristina* Larciprete[1]

[1]Dipartimento di Scienze di Base ed Applicate per l'Ingegneria, Sapienza Università di Roma, Rome, 00161, Italy

Abstract. In the present study, we focus into the infrared radiation (IR) absorption coefficients of several polymer types to propose a novel approach through the development of radiative-cooling polymeric films and composites. We will firstly describe the process of samples preparation. Afterwards, we will introduce the experimental setup employed for linear optical characterization in the infrared range along with the obtained experimental results. Finally, we will give details about the numerical model that we developed in order to evaluate the radiative cooling effectiveness of the different films.

1 Page layout

In the last years, environmental sustainability has emerged as the most challenging global issue. Among the different strategies, radiative cooling (RC) represents a promising approach to reduce global warming and to pursue clean energy. In detail, all bodies at any given temperature exchange heat with the universe, as it is the ultimate heat sink, through earth's atmosphere, allowing cooling without external energy. However, there are only two infrared atmospheric windows that allow emitted thermal infrared radiation to propagate without being absorbed by the water vapor dispersed into the atmosphere, namely 3-5 and 8-12 micron. Furthermore, the sun (~6000 K) represents the ultimate heat source therefore all bodies absorb solar energy and convert it into heat energy, so called photothermal effect. From another perspective, the high infrared radiation emitted during this cooling process can also serve as a valuable source of thermal energy.

In recent years, radiative cooling has gained increasing attention for its potential to mitigate global warming by reducing energy consumption in ventilation, and air conditioning systems within buildings or vehicles [1]. Polymeric materials, characterized by high emissivity values in the infrared range, and easiness of fabrication, are crucial in advancing radiative cooling technologies. Automobile air conditioning systems use is identified as the largest contributor to the auxiliary energy consumption of cars (i.e. the part that is not used for propelling the vehicle), and hence has a great influence on fuel economy and associated emissions. In terms of energy saving numerous studies were carried out to improve the efficiencies in thermal transfers. Among those, radiative cooling has attracted tremendous interest because it enables materials to passively cool the surface without consuming energy.

As already mentioned, although the infrared radiation covers a very wide wavelength range, only some part is transmitted through the atmosphere, which falls within the two transparency windows. The remaining IR radiation is mostly absorbed by water vapour and CO2 dispersed in the atmosphere. In order to get efficient radiative cooling, the surface of the material should have high emissivity values in the transparency windows in the atmosphere which lies between 3 – 5 μm and 8 – 13 μm while simultaneously attenuating emissivity between 5-8 μm. As a consequence of such emissivity spectral behaviour, the infrared radiation which is thermally emitted from the surface to the surrounding space, can efficiently lead to surface cooling in a passive way. Furthermore, reduced absorption of incoming solar irradiation (visible range and near infrared, NIR) is also appreciated.

While most research has focused on optimizing the structural and geometric effects to enhance selective wavelength absorption and infrared emissivity, the investigation of polymeric materials for radiative cooling applications has been relatively limited. More recently, polymer-based radiative coolers have been intensively investigated and experimentally demonstrated because transparent polymers can feature low absorption in the solar spectral range along with high emissivity in the IR region due to the typical infrared fingerprint of organic molecules. Last not least,

* Corresponding author: vijayasimhareddy.ireddy@uniroma1.it

polymers are easy to be manufactured with a large area and at relatively low cost.

In this work, we investigate a series of free-standing polymeric films with prepared by drop casting and lifting-off technique. Our research starts from the preparation of some polymeric films starting from raw granulate and infrared characterization of some IR polymer films for selective IR radiation. Optical characterization has been performed at room temperature in the Mid-infrared range. Reflectance spectra, measured via FTIR highlight the The resulting films demonstrated promising radiative cooling performance as evaluated through the typical infrared transparency windows of IR radiation in the atmosphere. Finally, we employ detailed numerical modelling to evaluate the radiative cooling performance of the investigated films for both emissive and absorbance behaviour.

References

1. Keng-Te Lin, Jihong Han, Ke Li, Chunsheng Guo, Han Lin, Baohua Jia, Nano Energy **80** 105517 (2021)