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Preparation and properties of temperature sensitive paint based on $Eu(DBM)_3phen$ as probe molecule

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Abstract: Probe molecule $Eu(DBM)_3phen$ was made up of europium oxide (Eu_2O_3), dibenzoylmethane (DBM) and 1,10-phenanthroline(phen). The temperature sensitive paint (TSP) was compounded by the polymerization of the probe molecule, methyl methacrylate (MMA) and the initiator of benzoyl peroxide (BPO). The structure, morphology, luminescence property of probe molecule and the temperature quenching property of the temperature sensitive paint (TSP) were characterized by infrared spectrometer, UV-vis spectrometer, scanning electron microscopy and fluorescence spectrometer respectively. The infrared spectrum and UV-vis spectra show that Eu and DBM form six membered rings, and Eu–O coordinate bonds form. The nanocrystals are in sphere-like morphology with an average size of approximately 100 nm. Fluorescence spectra present that the performance of temperature quenching is excellent, what's more, TSP sample has different temperature sensitivity in various temperature scope. Particularly, under excitation of 286 nm, TSP has a highest temperature sensitivity between 50 and 60 °C, and the strongest fluorescence emission reaches a peak (615 nm). It indicated that probe molecule ($Eu(DBM)_3phen$) has strong luminescent intensity and the temperature quenching properties of $Eu(DBM)_3phen$/PMMA is good.

Keywords: Probe molecule; Temperature sensitive paint; Temperature quenching; Dibenzoylmethane; rare earths

1. Introduction

Temperature sensitive paint (TSP) is luminescent polymer thin film for measuring surface temperature field in aerodynamic experiments. It is based on thermal luminescence quenching process which decreases the quantum efficiency of the luminescence process, and thus decreases the luminescent intensity with increasing temperature. Compared to conventional temperature measurement techniques, TSP is able to provide noncontact, high-resolution and temperature distribution on aerodynamic surface[1-3]. Therefore, experimental aerodynamicists can use TSP as a powerful measurement temperature tool to investigate rich physical phenomena in complex flows around flight vehicles.

TSP contains a temperature sensitive luminophore of probe molecule and polymer matrix[4]. The probe molecule plays an important role in TSP. The fluorescence characteristics and temperature sensitivity of the probe molecules are the key to the study of the temperature sensitivity of the TSP. The unique 4f structure of rare earth ions determines their luminescent properties and has better luminescence properties when they are combined with some organic ligands. Therefore, rare earth complexes have been widely used in luminescence field. At present, many work has been done on the selection and properties investigation of temperature sensitive probes including the complexes of europium, ruthenium, platinum, rhodamines and so on[5–7]. The matrix should have the following characteristics: (1) the matrix should have non-oxygen permeability to prevent oxygen quenching; (2) the matrix cannot interact with probe molecules to prevent the decrease of probe molecule activity; (3) the matrix should have higher stability to prevent cracking and influence of TSP's performance. The matrix of TSP is the most widely known, such as PMMA, shellac and styreneetc[8-9].

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