Stability Enhancement of Polymeric Sensing Films Using Fillers

Enhanced stability of polymer sensing films is achieved by adding colloidal fillers.

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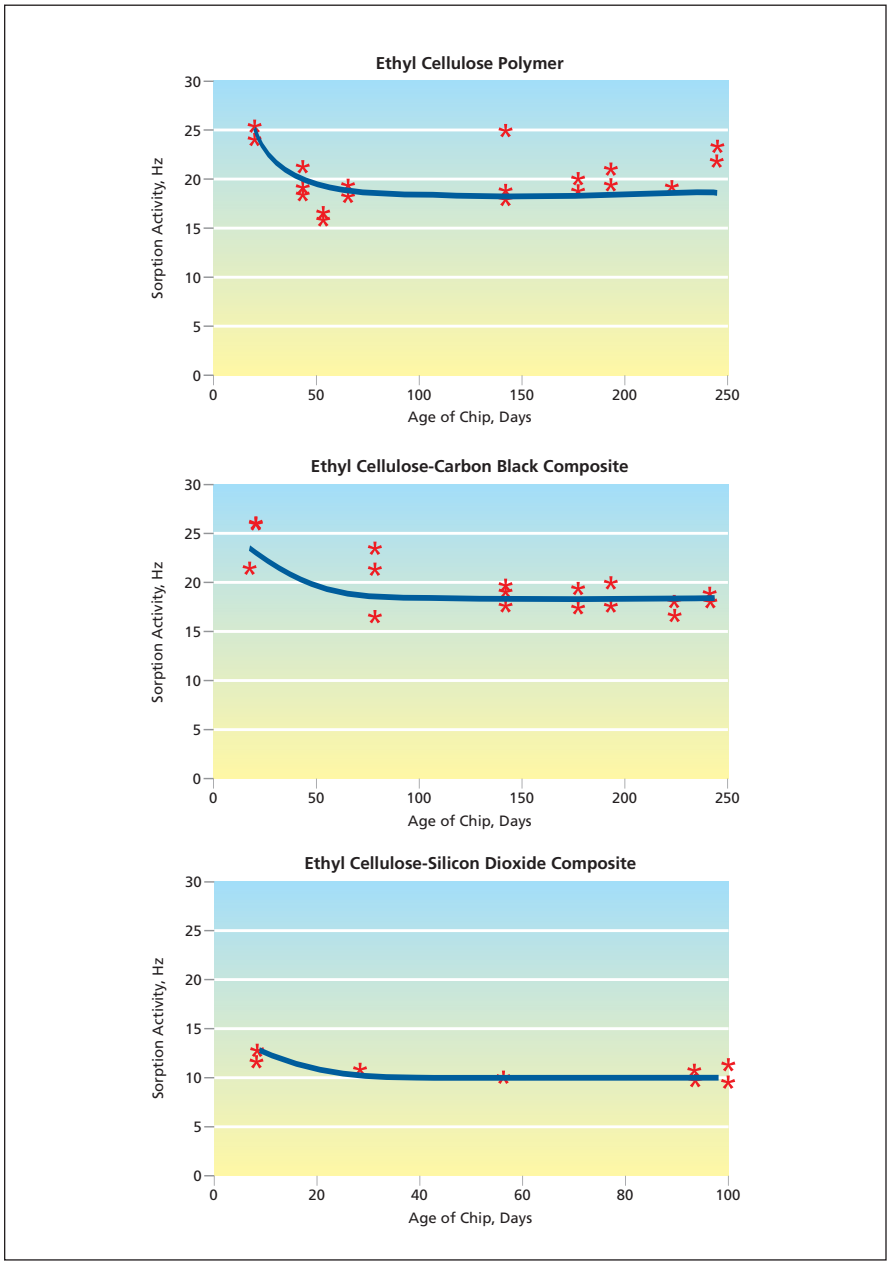
Experiments have shown the stability enhancement of polymeric sensing films on mixing the polymer with colloidal filler particles (submicron-sized) of carbon black, silver, titanium dioxide, and fumed silicon dioxide. The polymer films are candidates for potential use as sensing media in micro/nano chemical sensor devices. The need for stability enhancement of polymer sensing films arises because such films have been found to exhibit unpredictable changes in sensing activity over time, which could result in a possible failure of the sensor device.

The changes in the physical properties of a polymer sensing film caused by the sorption of a target molecule can be measured by any of several established transduction techniques: electrochemical, optical, calorimetric, or piezoelectric, for example. The transduction technique used in the current polymer stability experiments is based on piezoelectric principles using a quartz-crystal microbalance (QCM). The surface of the QCM is coated with the polymer, and the mass uptake by the polymer film causes a change in the oscillating frequency of the quartz crystal.

The polymer used for the current study is ethyl cellulose. The polymer/polymer composite solutions were prepared in 1,3 dioxolane solvent. The filler concentration was fixed at 10 weight percent for the composites. The polymer or polymer composite solutions were cast on the quartz crystal having a fundamental frequency of about 6 MHz. The coated crystal was subjected to a multistage drying process to remove all measurable traces of the solvent.

In each experiment, the frequency of oscillation was measured while the QCM was exposed to clean, dry, flowing air for about 30 minutes, then to air containing a known concentration of isopropanol for about 30 minutes, then again to clean dry air for about 30 minutes, and so forth. This cycle of measurements for varying isopropanol concentrations was repeated at intervals for several months.

The figure depicts some of the sensing film stability results for ethyl cellulose polymer, ethyl cellulose-carbon black, and ethyl cellulose-silicon dioxide composite systems. An ethyl cellulose film exhibited a marked decline in response in the first few months of study and settled to a steady average response after about four months. However, response varied widely around the average response for ethyl cellulose film. In contrast, ethyl cellulose-carbon black and ethyl cellulose-silicon dioxide composites also declined in the early months, but showed more repeatable sensing film activity after the initial decline. Similar trends were observed in experiments for ethyl cellulose-titanium dioxide and ethyl cellulose-silver composites.



Graphs Show Sensing Stabilities of ethyl cellulose polymer and ethyl cellulose-composite sensing films to the detection of 600 ppm of isopropanol. As compared to the stability of ethyl cellulose polymer, the ethyl cellulose-carbon composite and ethyl cellulose-silicon dioxide composite show greater stability with time. The lines drawn are to guide the eye.

This work was done by Brian Lin, Abhijit Shevade, Margaret Amy Ryan, Adam Kisor, Shiao-Pin Yen, Kenneth Manatt, Margie Homer, and Jean-Pierre Fleurial of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1). NPO-40518*