

Color-changing material indicates when medications get too warm

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Appearing green on a vial lid (left), this structural color material becomes

colorless (right) when warmed. Credit: Adapted from *ACS Nano* 2023, DOI: 10.1021/acsnano.3c00467

Some foods and medicines, such as many COVID-19 vaccines, must be kept cold. As a step toward a robust, stable technique that could indicate when these products exceed safe limits, researchers in *ACS Nano* report a class of brilliantly colored microcrystals in materials that become colorless over a wide range of temperatures and response times. As a proof of concept, the team packaged the color-changing materials into a vial lid and QR code.

Walk-in freezers and refrigerated trucks generally maintain their set temperatures, but accidents can happen. Wireless sensors can monitor the temperature of individual products, but these devices produce a lot of electronic waste.

Recently, researchers have suggested using [materials](#) that act as visual indicators to provide this information with less waste. Yet some current options using colorful reactions or dyes produce hues that can fade, or they only track above-freezing temperatures, which isn't useful for some COVID-19 vaccines that can actually start breaking down below freezing—above -4° or -94° Fahrenheit. So, Yadong Yin, Xuemin Du and colleagues wanted to develop a better color-changing material with tunable melting to track a wide range of temperatures.

The researchers used [structural colors](#), instead of dyes, for their indicator system. The team made glycerol-coated silicon dioxide nanoparticles, which appeared bright green or red when they clustered together into microcrystals in water. Next, they created liquids with variable melting points by mixing different proportions of polyethylene glycol or [ethylene glycol](#) and water. When these two parts were put together, they could

produce an irreversible color loss when the temperature-triggered solution melted and the microcrystals broke apart.

The materials could be customized to track temperature exposures from -94° to $+99^{\circ}$ Fahrenheit that lasted from a few minutes to multiple days. In other experiments, the two-part indicator systems were packaged into flexible round vial labels and a QR code. These systems were very sensitive and successfully indicated when the materials got too warm. The researchers say that structural color-changing materials hold promise for the diverse scenarios encountered in medical cold supply chains.

More information: Chao Huang et al, Self-Destructive Structural Color Liquids for Time-Temperature Indicating, *ACS Nano* (2023).
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