

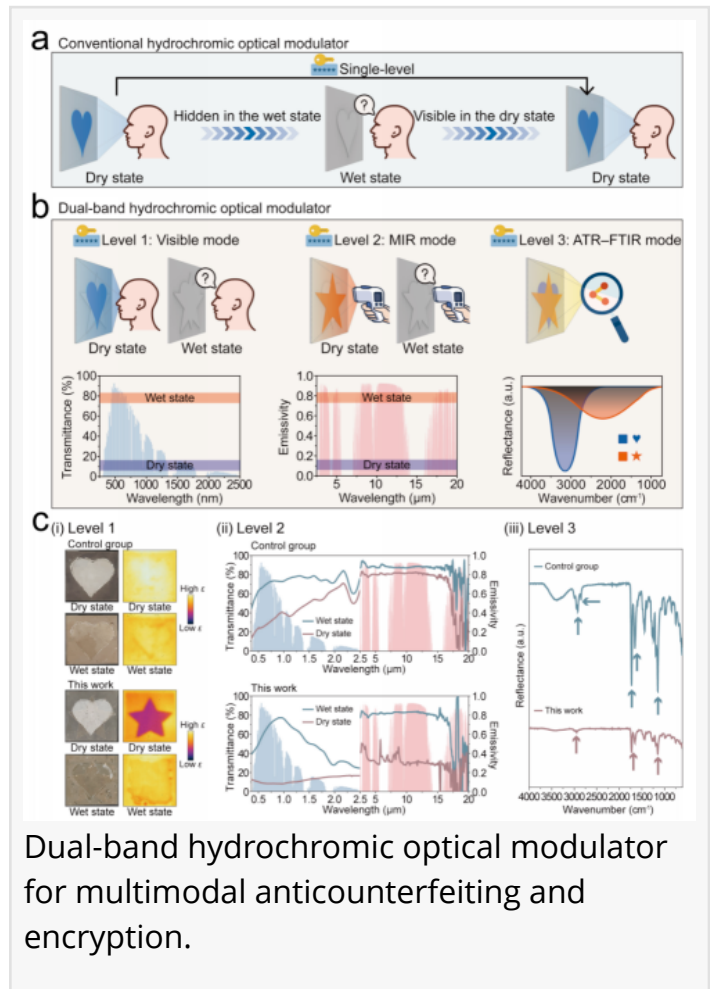
Dual-band hydrochromic optical modulator for multimodal anticounterfeiting and encryption

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/EINPresswire.com/ -- This study presents a scalable [dual-band hydrochromic](#) optical modulator that uses water and humidity to switch information across visible, mid-infrared, and chemical spectral channels. By integrating a porous polymer with a low-emissivity layer, the device enables multi-level anticounterfeiting and encryption with strong transmittance and emissivity modulation. Its reversible response, flexible format, and durability under cycling, heat, ultraviolet (UV), and saltwater exposure support practical security applications.

Counterfeiting and information leakage are growing problems in modern society, affecting products such as banknotes, medicines, consumer goods, security labels, and confidential documents. Conventional anticounterfeiting technologies, including printed codes, color changing inks, and single mode optical labels, often rely on only one visible signal. Because such signals can be easily observed and copied, there is an increasing need for more secure materials that can hide and reveal information through multiple independent channels.

In a new paper(doi: <https://doi.org/10.37188/lam.2026.079>) published in Light: Advanced Manufacturing, a team of scientists led by Professor Yi Long from The Chinese University of Hong Kong and Professor ZhiLi Dong from Nanyang Technological University developed a dual-band hydrochromic optical modulator for multimodal anticounterfeiting and encryption. The device uses water and humidity as simple external triggers to control optical information in both the visible and mid-infrared regions. It also provides a chemical authentication mode based on attenuated total reflection Fourier transform infrared spectroscopy.



The key idea of this work is to move hydrochromic anticounterfeiting beyond conventional visible only switching. Most reported hydrochromic materials change their color or transparency when exposed to water, but their response is usually limited to the visible region. This single band design may not provide enough security for advanced authentication. In contrast, the newly developed platform combines a porous polymer layer with a low emissivity layer, enabling information to be encoded and verified through three different modes.

In the first mode, the device changes its optical appearance in the visible region. In the dry state, the porous polymer strongly scatters light and appears opaque. When water enters the pores, light scattering is reduced and the device becomes more transparent. This water-triggered change allows hidden visible information to be revealed or erased. In the second mode, the device changes its mid-infrared emissivity. The dry state shows low emissivity, while the wet state shows much higher emissivity because of water absorption in the infrared region. This enables hidden thermal patterns to be detected using an infrared camera. In the third mode, the device can be authenticated by its chemical signatures using ATR-FTIR spectroscopy, providing an expert-level verification channel.

The researchers fabricated the device through a scalable water-in-oil emulsion process followed by spin coating. This simple process allows porous polymer structures to be formed on low-emissivity substrates and can be applied to flexible films. The optimized device achieved strong dual-band modulation, including up to 47.2 percent luminance transmittance modulation and 0.55 mid-infrared emissivity modulation between the dry and wet states. The device also showed a reversible response to both direct water contact and changes in relative humidity.

The team further demonstrated proof of concept anticounterfeiting prototypes with different hidden patterns. Some information could be seen by the naked eye after water exposure, while other information could only be detected by infrared imaging or ATR-FTIR spectroscopy. This layered authentication strategy makes the information more difficult to copy because successful verification requires not only the correct visible response but also the correct infrared and chemical signatures.

The device also showed strong environmental stability. It maintained stable optical modulation after repeated dry and wet cycling and after exposure to harsh conditions, including high temperature, ultraviolet irradiation, and saltwater. These results suggest that the platform may be suitable for practical security labels, flexible anticounterfeiting devices, information encryption, humidity responsive optical systems, and smart photonic materials.

This work provides a simple but effective strategy for building multimodal anticounterfeiting systems. By integrating water responsive visible switching, infrared emissivity modulation, and chemical signature authentication into one flexible device, the study opens a pathway toward more reliable, scalable, and difficult to replicate security technologies.

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