NanoInnovation 2026

Gold Nanorod-Functionalized Smart Patches for Light-Triggered On-Demand Drug Delivery

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Abstract

Transdermal drug delivery systems (TDDS) represent a valuable alternative to oral and injectable routes of administration, offering significant advantages, including non-invasive delivery, avoidance of first-pass metabolism, improved patient compliance, and sustained drug release. TDDS enter the body via passive diffusion across the stratum corneum into local blood vessels.

This study explores the development of a gold nanorod (AuNRs) functionalized Patch platform designed for on-demand drug delivery. The integration of AuNRs onto a flexible wound-dressing substrate was achieved through a controlled, water-based drop-casting process, enabled by a preliminary wettability-enhancement treatment.

The resulting AuNRs-functionalized Patch was designed to absorb, contain, and controllably release the loaded drug in response to external NIR light-triggered heating. AuNRs are highly attractive photothermal agents due to their tunable surface plasmon resonance (SPR), excellent photothermal conversion efficiency, and biocompatibility. Upon NIR laser irradiation, AuNRs generate localized heat through SPR excitation, triggering thermally induced release of the loaded drug potentially driven by heat-induced shrinkage of the substrate.

The AuNR-functionalized patch was characterized using scanning electron microscopy, UV–Vis spectroscopy, diffuse reflectance spectroscopy, and emission spectroscopy. Its photothermal performance was evaluated under 808 nm NIR irradiation by monitoring temperature change over time using a high-resolution thermal camera. The temperature increase to 42°C after 45 min of NIR irradiation, is enough to induce controlled release of the model molecule Rhodamine B (RhB), as well as the therapeutic drug Estradiol, monitored by fluorescence spectroscopy, supporting its suitability for localized treatment. These findings demonstrate the potential of the AuNRs-functionalized Patch as an affordable, wearable platform for NIR-triggered localized drug delivery.