Construction and investigation of all-in-one microneedles complexed with functionalized polydiacetylene liposomes

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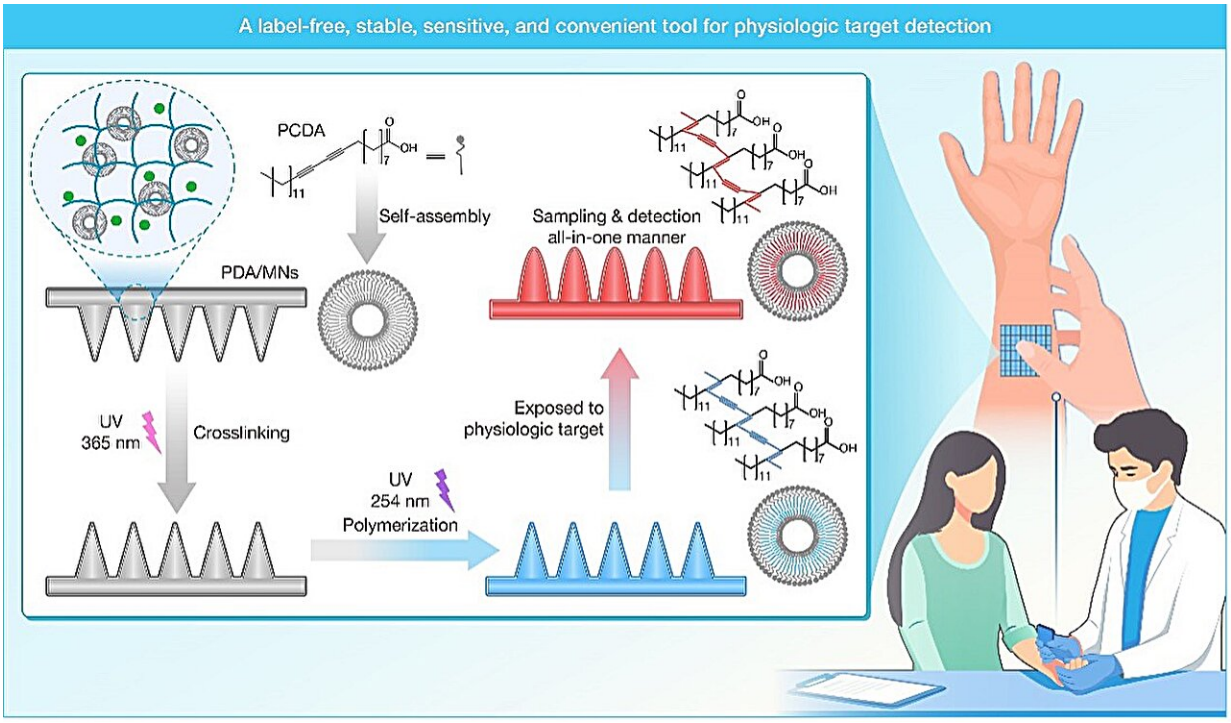

PDA liposomes were blended with MNs pre-solution to construct complexed microneedles (PDA/MNs). And the PDA liposomes turned out to be blue after irradiation at 254 nm. Perturbation of the PDA-conjugated backbone in response to external factors led to the color transition and fluorescence emission of PDA liposomes. Credit: Prof. Ming Kong, College of Marine Life Science, Ocean University of China

Researchers have developed a novel detection platform that complexed polydiacetylene (PDA) liposomes with swellable microneedles (MNs) for the sensitive and non-invasive detection of biomarkers. The PDA liposomes, prepared using 10,12-Pentacosadiynoic acid (PCDA), exhibit unique optical properties that change in response to external stimuli such as temperature and pH. These changes include color shifts and fluorescence signal generation, which are harnessed for detection purposes.

To address the limitations of PDA liposomes in liquid-phase matrices, such as dilution effects and poor stability, the researchers, led by Dr. Ming Kong (Ocean University of China) and Dr. Junmin Lee (Pohang University of Science and Technology), combined them with swellable microneedles to construct a solid-phase detection system, enabling integration of target sampling and detection in one platform.

The work, "Construction and investigation of all-in-one microneedles complexed with functionalized polydiacetylene liposomes for improved in situ detection sensitivity," is published in the journal *hLife*.

The microneedles, made from methacrylated hyaluronic acid (MeHA), were optimized for mechanical and swelling properties, facilitating the absorption of interstitial tissue fluid (ISF) for biomarker detection.

The PDA/MNs demonstrated enhanced pH sensing capabilities, with a noticeable color change from blue to red and an increase in fluorescence intensity as pH levels rose above 8, validating the feasibility of PDA/MNs as an integration platform for the sampling and detection process.

For the detection of lead ions (Pb^{2+}), dopamine-derived diacetylene monomer (DA-PCDA) was co-prepared with PCDA in liposomes (DA-PDA). The DA-PDA liposomes showed a linear increase in colorimetric

response and fluorescence intensity with increasing Pb^{2+} concentration, enabling quantitative analysis.

When integrated into microneedles (DA-PDA/MNs), the limit of detection (LOD) was significantly lowered compared to those in liquid-phase matrices.

Similarly, for the detection of sialic acid (SA), diacetylene monomers were functionalized with phenylboronic acid and amino groups to obtain EPE-PDA liposome. Combined with microneedles (EPE-PDA/MNs), the platform could extract SA from simulated skin and achieve quantitative detection with a lower LOD than in liquid-phase matrices.

The linear detecting range covers either normal or pathogenic serum SA level, indicating EPE-PDA/MNs are sensitive and feasible to be applied for clinical SA detection.

The detecting capacity of PDA/MNs could be tailored according to specific targeting molecule by chemical modification of diacetylene monomers, making it a flexible platform to provide a label-free, stable, sensitive, and convenient tool in an all-in-one manner for physiologic target detection.

More information: Jiarui Wang et al, Construction and investigation of all-in-one microneedles complexed with functionalized polydiacetylene liposomes for improved in situ detection sensitivity, *hLife* (2024). DOI: 10.1016/j.hlife.2024.07.005

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