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Photothermal Activation of Gold Nanoparticles Star-shaped Induces Calcium Release in T-lymphocytes

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Calcium ions (Ca^{2+}) are critical secondary messengers in T cells, governing activation, gene expression, and effector functions. Precisely manipulating intracellular Ca^{2+} levels is a powerful but challenging approach for studying immunology and developing therapies for immune-related diseases.
We utilised the unique photothermal properties of gold nanostars (AuNSs), which were internalised by Jurkat T cells. Upon irradiation with a laser tuned to the AuNSs' absorption peak, the nanoparticles converted light to heat, inducing a localised temperature increase.
This photothermal stimulus triggered a rapid and significant release of intracellular Ca^{2+}. Real-time live-cell imaging using a Ca^{2+}-binding fluorophore revealed a distinct fluorescence peak corresponding to the laser stimulus. Co-localisation studies indicated that the initial Ca^{2+} microdomains originated from lysosomal stores, subsequently amplifying into a global cellular signal.
We demonstrate a novel, non-invasive method for the precise spatiotemporal control of Ca^{2+} signalling in T cells using photothermal nanoparticles. This technique provides a valuable tool for probing fundamental immunology and has promising therapeutic potential for modulating immune responses in cancer, autoimmunity, and inflammation.

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