Nanoadjuvants: From Nanocarriers to Immunomodulators

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Adjuvants play a critical role in enhancing the efficacy of vaccines by inducing stronger immune responses against antigens. However, the lack of adjuvants capable of eliciting potent cellular immunity remains a major challenge for the development of vaccines against cancer and infections. In this study, we aimed to design a next-generation Nanoadjuvant platform technology using surface engineered silica-based nanoparticles to not only act as nanocarriers for antigen delivery but also as immunomodulators to enhance vaccine efficacy.

Our research team synthesized sodium-stabilized dendritic mesoporous aluminosilicate nanoparticles (Na-^{IV}Al-DMSN) and investigated their ability to induce dendritic cell (DC) pyroptosis-mediated protective immunity. We made two key innovations: (1) Firstly, we synthesized Na-^{IV}Al-DMSN, a new material, using a simple chemical reaction between aluminate and silicate. This material possesses framework-stabilized sodium that can exchange protons, a large mesopore of ~ 30 nm, and a uniform particle size of ~ 240 nm. A PCT Patent has been filed, indicating the novelty and significance of our innovation. (2) Second, we have elucidated the structure-function relationship of Na-^{IV}Al-DMSN, which induces H+/Na+ exchange in acidic lysosomes, leading to lysosome rupture and K+ efflux. This mimics the process by which natural viral infections occur, where pyroptosis is triggered in antigen presenting cells, eliciting protective immunity.

Our designed nanoadjuvants demonstrated excellent antigen loading capabilities and induced enhanced T-cell responses and innate immunity in a prophylactic colorectal cancer mouse model. The use of mesoporous aluminosilicates as DC modulators and the underlying structure-function mechanism are novel in materials science and nanomedicine. Overall, this study provides a promising next-generation nanoadjuvant platform for vaccine applications that could contribute to the development of effective cancer and infection vaccines.

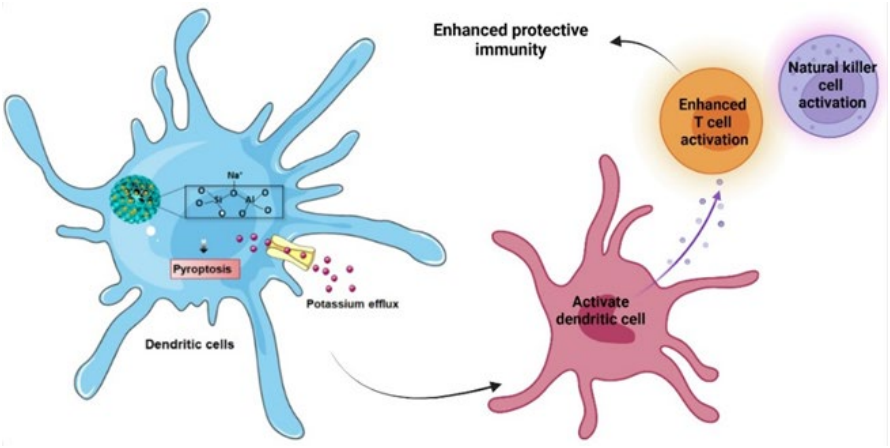

Figure 1. Mechanisms for Na-^{IV}Al-DMSN induced DC pyropotosis and hyperactivation for enhanced innate and adaptive immunity.

References:

[1] **Tang, Jie**, et al. *Chemical science* 13.29 (**2022**): 8507-8517.
[2] Yang, Yang, **Jie Tang***, et al. *Angewandte Chemie* 132, no. 44 (**2020**): 19778-19785.