Controlled Release of Extracellular Vesicles by Alginate Biomaterials

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BACKGROUND

Extracellular Vesicles (EVs) are nanometer-sized, lipid membrane–enclosed vesicles secreted by most, if not all, cells that contain lipids, proteins, and multiple nucleic acid species of the source cell. EVs have been shown to mediate biological processes such as tissue homeostasis, aging, cancer, wound healing, inflammation, and many others, typically as a paracrine signaling mechanism. Recently, a population of small EVs was identified within the extracellular matrix of non-mineralized tissues and in vitro cultures. These Matrix-Bound nanovesicles (MBVs) have been shown to possess therapeutic and immunomodulatory properties without cytotoxic effects, particularly in optic nerve repair, attenuation of periprosthetic osteolysis, and treatment of pristane-induced rheumatoid arthritis. MBVs are typically administered as bolus injections; their therapeutic potential is hindered by their rapid dispersal and lack of targeted delivery in the injection site due to their size (50-200 nm), resulting in premature systemic clearance from the body. Generally, EV therapies, including MBVs, are faced with a significant bottleneck in the rapid clearance of these particles from the body after injection (24-48 hours). Biomaterials have been used to control and localize the release of these particles; however, many biomaterials struggle to match physiological healing timeframes. There is a demonstrated need for EV therapies that offer retention of EVs for longer physiological healing timeframes.

DESCRIPTION

Researchers at the University of California, Santa Barbara have developed an innovative alginate hydrogel platform that enables tunable, sustained release of extracellular vesicles to match physiological healing timelines and improve therapeutic efficacy. This mechanically tunable alginate biomaterial system can encapsulate EVs with controlled release profiles by varying gel stiffness and stress relaxation rates. This platform retains nearly 100% of vesicles over 14 days, significantly extending retention compared to existing biomaterials that release EVs within days to weeks. By modulating alginate hydrogel properties, this technology addresses the challenge of rapid clearance of EVs and aligns their release with long-term tissue healing processes, such as bone repair, requiring months to heal. The bioinert and cyto-compatible alginate hydrogels enable customizable delivery, improving localized EV therapy efficiency and reducing systemic side effects.

ADVANTAGES

- Prolonged retention of extracellular vesicles—up to 14 days with near complete encapsulation
- Mechanically tunable hydrogel properties allowing precise control of release rates
- Biocompatible and versatile alginate biomaterial platform

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OTHER INFORMATION

KEYWORDS

regenerative medicine, medicine, tissue repair, extracellular vesicles, chronic injury treatment, EVs, hydrogel, healing, vesicles, bone repair, biomaterials, biologics, therapeutic delivery systems

CATEGORIZED AS

- **Medical**
  - Delivery Systems
  - Diagnostics
  - Disease: Autoimmune and Inflammation
  - Disease: Ophthalmology and Optometry
  - Rehabilitation
  - Therapeutics

RELATED CASES

2026-807-0

- Improved localization of EVs, minimizing rapid systemic clearance
- Alginate hydrogel platform can be administered via injection
- Customizable stiffness and stress relaxation for matching physiological healing timescales
- Compatibility with matrix-bound nanovesicles (MBVs) and nanoparticles for diverse applications

APPLICATIONS

- Regenerative medicine and tissue repair, especially bone and soft tissue healing
- Targeted delivery of extracellular vesicles for immunomodulation and anti-inflammatory therapies
- Wound healing and chronic injury treatment
- Drug delivery platforms requiring controlled nanoparticle release
- Biomaterials development for sustained release of biologics and cell-derived therapies
- Ophthalmology, orthopedics, and autoimmune disease therapeutic delivery systems

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Matrix-Bound Nanovesicles from In Vitro Cell-Derived Extracellular Matrix Sheets

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