LipoGels: Robust self-lubricating physically cross-linked alginate hydrogels embedded with liposomes

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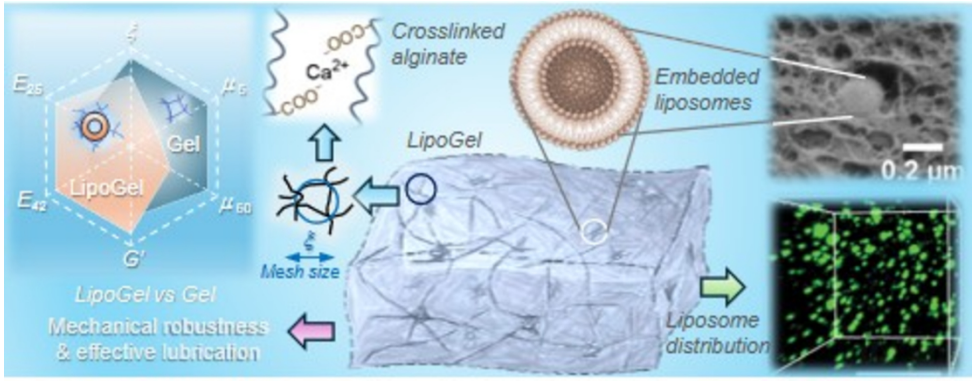
The exceptional lubrication devised by living systems (e.g. knee joints and eyelids) has stimulated intensive research into designing lubricating hydrogels and investigating the underlying mechanisms [1,2]. Current hydrogels for this purpose are typically *chemically* cross-linked, needing sophisticated synthesis and preparation procedures with a multitude of chemicals, which pose challenges in biocompatibility and sustainability.

Inspired by Klein's pioneering research [3], where lipid multilamellar vesicles were incorporated in synthetic hydrogels to facilitate cartilage-like lubrication, we have devised a facile method to incorporate ~100 nm 1,2-dipalmitoyl-sn-glycero-3-phosphocholine (DPPC) liposomes into a Ca^{2+} physically cross-linking sodium alginate hydrogel, which we term ' **LipoGel** ' [4]. Cryo-SEM and confocal fluorescence microscopy confirmed the uniform distribution of liposomes within a compact porous hydrogel network. Small-angle neutron scattering (SANS) revealed a classic de Genes' mesh size ξ ~3.8 nm, consistent with rheology-derived estimates, which yielded a shear elastic modulus G' 4 times that of chemically cross-linked hydrogels incorporating liposomes. The *LipoGels* exhibited robust mechanical strength with a Young's modulus E ~ 1 MPa from micro-indentation, comparable to some of the recent chemically cross-linked hydrogels. Underwater tribological tests demonstrated an ultra-low friction coefficient μ ~0.02, highlighting their self-lubricating capabilities of the *LipoGels* in the presence of trace amounts of lipids (~0.05-1 ppm). We further explore the effects of incorporating different types of liposomes, also comparing small unilamellar vesicles (USVs) with multilamellar vesicles (MLVs).

The facile yet effective gelation strategy for fabricating lubricating *LipoGels* with robust mechanical strength also emphasizes environmentally friendly processing and inherent biocompatibility. The versatility of this hydrogel system offers a platform for further exploration of the relationship between nano-structural features and lubrication effectiveness, opening up avenues for further biomedical applications.

Keywords:
Alginate hydrogels, biolubrication, liposomes, LipoGels, friction



Physically cross-linked alginate hydrogels embedded with DPPC liposomes (LipoGels) demonstrate robust mechanical strength, excellent lubrication, and stability under load, with inherent biocompatibility, transparency, and simple formulation.

References:

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