Surface Tuning of Primary Packaging Materials to Reduce mRNA-LNP-Adsorption

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Primary packaging plays a crucial role in the development of stable and safe pharmaceutical products. Particularly when it comes to packaging biological components, it is essential to minimize interactions between the packaging surface and the packaged components. Unwanted interactions between the pharmaceutical component and their packaging material can significantly affect the structure, integrity and final concentration of the biological active ingredients during storage.

LNPs are used as carrier systems to encapsulate biological therapeutics (such as mRNA) for protection and easier transport into the cells. They typically consist of a mixture of lipophilic and hydrophilic lipids, which makes it difficult to predict surface interactions and adsorption. The gold standard regarding primary packaging material for parenterals still to this day is borosilicate glass. Even though it shows excellent chemical resistance and inertness as well as excellent barrier against gases and vapor, its drawbacks are brittleness and possible breakage, glass delamination and the heavier weight which results in more complex handling and transportation. As far as polymeric materials as a mechanically more robust and environmentally friendly alternative, cyclo-olefin copolymers (COC) are increasingly used as primary packaging material. COC also exhibits high chemical inertness, low water vapor and gas permeability and shows minimal interaction with active pharmaceutical ingredients – especially compared to standard polymers like PP or PE.

This project focuses on developing surface treatments to investigate the possibility of tuning the surface properties of polymeric and glass materials to minimize mRNA-LNP adhesion. The results show that plasma-based coatings can be a useful tool to neutralize surfaces which could be shown by measuring the isoelectric point of various materials before and after coating processes. Initial fluorescence-based detection of PolyA-LNP adhesion demonstrated residual signals on glass and polymer substrates after storing PolyA-LNPs on the surface and binding lipophilic fluorescence markers onto the surface. After coating these materials using PEG-Silane a reduction of unspecific adsorption processes could be detected (see Figure 1). These findings underline the influence of surface chemistry on biomolecule and LNP interactions, guiding future packaging materials design. The resulting insights will steer the future design of optimized packaging surfaces.

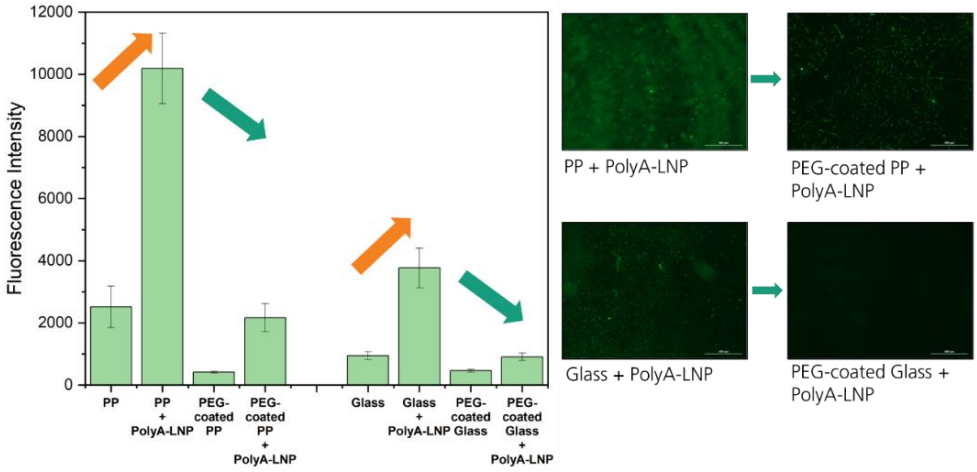

Figure 1: Preliminary adsorption tests of PolyA-LNPs on PEG-coated glass and Polypropylene

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