Lipid Nanoparticles, Key Component of COVID-19 mRNA Vaccines

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Lipid nanoparticles have been developed as vehicles for small molecule delivery by the nanomedicine and materials communities and are now a key component of COVID-19 mRNA vaccines.

Vaccines against COVID-19 have been developed with unprecedented speed. In particular, mRNA vaccines — a technology already in clinical trials for other infectious diseases, such as influenza — have shown impressive efficacy in clinical trials.

mRNA vaccines rely on the delivery of mRNA into the cytoplasm of host cells, where it can be transcribed into antigenic proteins to trigger the production of neutralizing antibodies. However, mRNA is three to four orders of magnitude larger than molecules that readily diffuse into cells; in addition, the dense negative charge of mRNA electrostatically repulses the anionic cell membrane, preventing its uptake. Therefore, mRNA vaccines require a delivery vehicle that not only protects the nucleic acid from degradation but allows the mRNA to get into cells.

BioNTech/Pfizer’s and Moderna’s mRNA vaccines both use lipid nanoparticles as mRNA carriers. The impressive speed at which these vaccines could be developed is partly owed to the fact that nucleic acid delivery by lipid nanoparticles has long been investigated and optimized by the nanomedicine community, who thoroughly studied lipid nanoparticle chemistry, structure, surface, injection routes, uptake, endosomal escape, cargo release, dosage, clearance and, importantly, safety.

Owing to their size and properties, lipid nanoparticles are taken up by cells via endocytosis, and the ionizability of the lipids at low pH (likely) enables endosomal escape, which allows release of the cargo into the cytoplasm. In addition, lipid nanoparticles usually contain a

helper lipid to promote cell binding, cholesterol to fill the gaps between the lipids, and a polyethylene glycol (PEG) to reduce opsonization by serum proteins and reticuloendothelial clearance. The relative amounts of ionizable lipid, helper lipid, cholesterol and PEG substantially affect the efficacy of lipid nanoparticles, and need to be optimized for a given application and administration route.

It was a long road to optimizing lipid nanoparticle formulations for nucleic acid delivery. To achieve clinical efficacy, every aspect of the lipid nanoparticle formulation had to be optimized, and more than 300 ionizable lipids had to be screened. Furthermore, all key steps of the lipid nanoparticle journey in the body had to be understood before clinical trials could begin. This knowledge has certainly contributed to the rapid development of COVID-19 mRNA vaccines.

From a materials science perspective, the success of lipid nanoparticle mRNA vaccines is exciting and important, as it underlines the value of materials science for medical advances and motivates further fundamental and applied nanoparticle research, which will hopefully be reflected in future funding cycles.

Huateng Pharma, a professional PEG supplier, is dedicated to manufacturing and supplying a wide range of PEG derivatives. Lipid nanoparticles is a key component of COVID-19 mRNA vaccines. We can supply below PEG products which are excipients used in COVID-2019 vaccine.