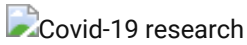
# Understanding the nanotechnology in COVID-19 vaccines




Covid-19 related research

*By Rumiana Tenchov, Information Scientist, CAS Posted February 18, 2021*

Lipid nanoparticles are a vital component of the new Pfizer/BioNTech and Moderna mRNA COVID-19 vaccines, playing a key role in protecting and transporting the mRNA effectively to the right place in cells. They are next generation liposomes that use nanotechnology and are well suited to stable and efficient delivery of various therapeutics.

Although mRNA vaccines have received much global interest as they are a new type of drug, lipid nanoparticles have held a recognised position in the mainstream of drug delivery systems (DDS) since the discovery of liposomes in the 1960s. Let us take a closer look at what liposomes are, their evolution and potential for use in other industries.

## Liposomes – the precursor to lipid nanoparticles

Liposomes are closed lipid bilayer vesicles that spontaneously form in water (see fig. 1A) – essentially a fatty capsule. They were discovered in the 1960s and their potential as effective drug delivery systems was almost immediately recognized. Throughout the last few decades scientists have worked on the design of liposomes to control where they act, how long they circulate in the body, and where and when their contents are released.

Liposomes have proven to be an extremely versatile nanocarrier platform because they can transport either hydrophilic drugs within the enclosed aqueous interior, or hydrophobic drugs within the hydrocarbon chain region of the lipid bilayer (see fig. 1B).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They are enormously important in therapeutics, driving medicine forward, and have been used in numerous clinical trials for anticancer, anti-inflammatory, antibiotic, antifungal, and anaesthetic drug delivery as well as for the delivery of gene therapies. In fact, liposomes are the first nanomedicine delivery platform to successfully move from concept to clinical application. There are a number of approved pharmaceutical preparations, for example, Doxil for the delivery of the chemical inhibitor doxorubicin to treat ovarian cancer and Epaxal for the delivery of protein antigen as a hepatitis vaccine, and many more in the pipeline. Understanding how they have been developed will help us unlock potential future uses.


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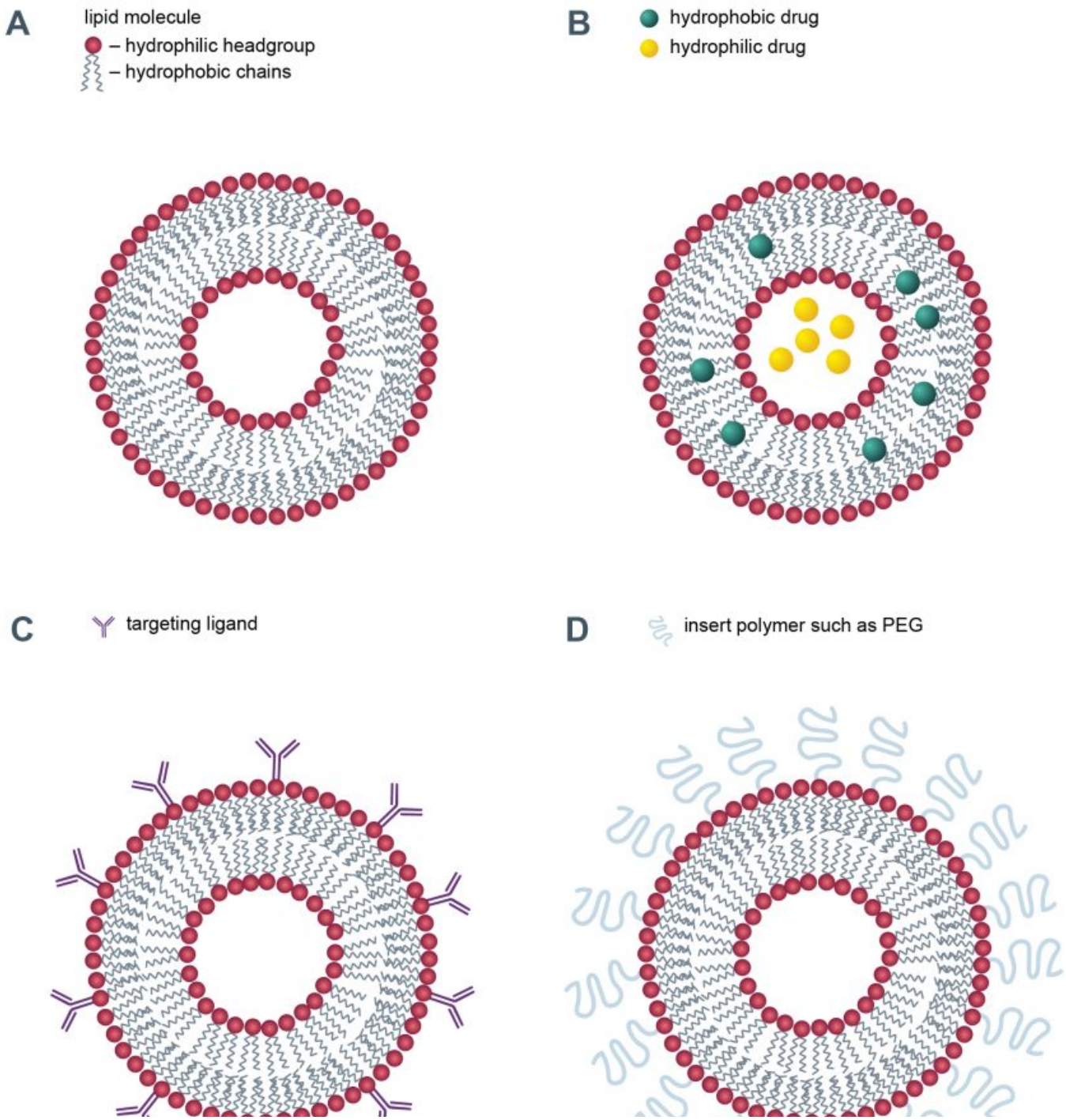


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*Fig. 1. Schematic representation of: (A) liposome; (B) liposome encapsulating hydrophobic and hydrophilic drugs; (C) immunoliposome functionalized with targeting ligands; (D) sterically stabilized ("stealth") liposome functionalized with inert polymers such as PEG.*

## Evolution as a targeted drug delivery system

Despite their benefits, liposomes have a couple of disadvantages: they have a short circulation time in blood stream, are unstable in the human body, and lack selective targeting. There have been several key developments to their construction to overcome these challenges:

1. To enhance tissue targeting, the liposomes' surface has been modified with ligands or antibodies which allow the liposome to recognise and bind to specific receptors on the cells (Fig 1C). These are referred to as immunoliposomes.
2. To improve their longevity in the blood stream, the surface has been coated in biocompatible inert polymers such as PEG (Fig 1D), which goes undetected.
3. To provide controlled release of the encapsulated drug, scientists have designed stimuli-responsive liposomes which are sensitive to temperature and pH levels. The membrane permeability is enhanced during a stimuli-triggered phase transition of the lipids in formulations.

Lipid nanoparticles have a more complex internal lipid architecture and minimal internal aqueous presence than traditional liposomes. Further enhanced physical stability has been achieved by the development of solid lipid nanoparticles (SLN) and nanostructured lipid carriers(NLC), addressing one of the main limitations of emulsion-based formulations. Cubosomes are the most recent improvement which are highly stable nanoparticles formed from a lipid in cubic phase and stabilised by a polymer-based outer corona. Continue reading here

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