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A new advancement technique for the formation of highly uniform engineered functional nanoparticles with pharmaceuticals tailored properties by membrane dispersion cell

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A new advanced membrane technique for the formation of highly uniform functional nanoparticles with tailored properties suitable for high-value pharmaceutical applications



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1. Research highlight: What is functional nanoparticle?

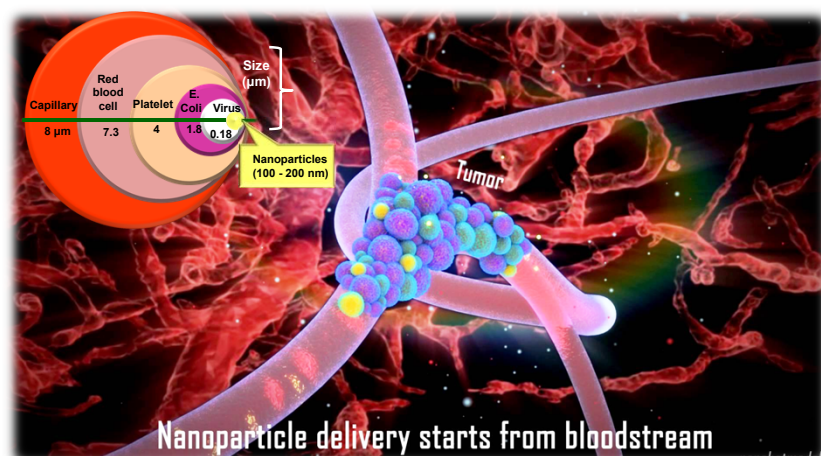


Fig. 1: Functional NPs administration route mechanism depending on their particle size without causing an embolism.

Functional nanoparticles (NPs) are scientifically defined as solid, colloidal particles or carriers in the range **10-1000 nm** [1] with numerous functions such as; (i) **protections of active ingredients** (drugs) against degradation, (ii) **targeting of drugs** to specific sites of action (organ or tissue), and (iii) **delivery of biological molecules** such as proteins, peptides and oligonucleotides depending upon their administration routes either orally, parenterally or locally [2].

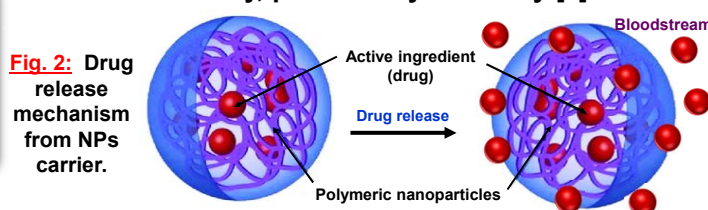


Fig. 2: Drug release mechanism from NPs carrier.

2. New advancement techniques: Membrane system & nanoprecipitation method

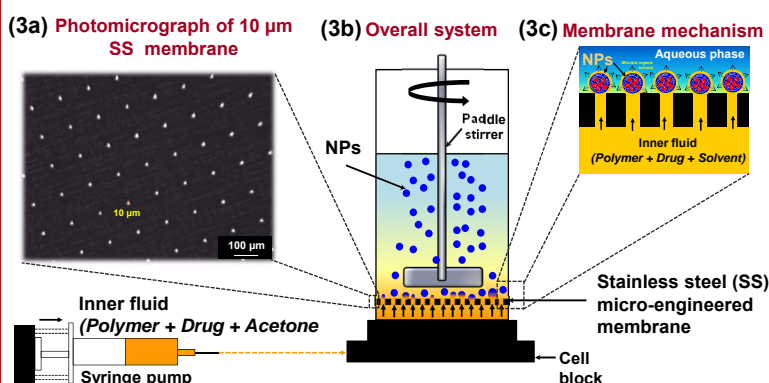


Fig. 3: Schematic diagram of the experimental setup.

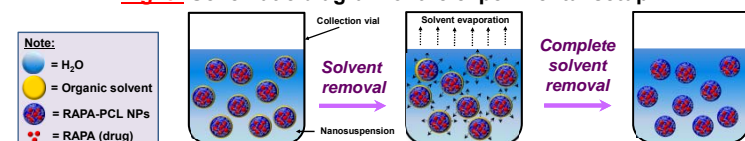


Fig. 4: Solvent removal mechanism of final polymeric NPs product.

NPs were produced instantaneously by **fast diffusion** (nanoprecipitation) once the **organic phase** is introduced through the membrane pores coming into contact with the **aqueous phase** that flows tangentially to the membrane surface.

3. Materials and parameters setting

Table 1. Experimental materials/parameters.

Subjects	Materials/Properties	Compositions/Remarks
Aqueous phase	Mili-Q-water + surfactant	(Depending on V_{aq}/V_{org})
Organic phase	Dissolved mixture of polycaprolactone (PCL) + drug (rapamycin) in acetone	6 g/l PCL + 40 w/w% rapamycin (RAPA)
Membrane	Pore size = 10 µm	Stainless steel (SS) membrane
Optimum exp. parameters	(i) Volume ratio (V_{aq}/V_{org}) (ii) Stirring speed (rpm) (iii) Injection rate (ml/min)	(i) 10.0 (ii) 1300 rpm (iii) 5 ml/min

4. NPs physical characterisations & images

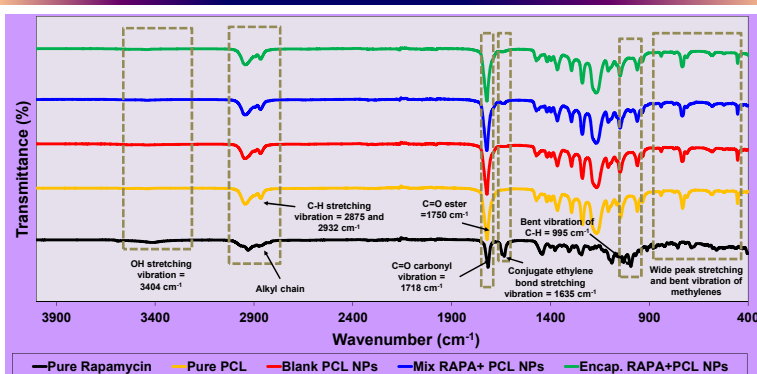


Fig. 5: Attenuated total reflectance Fourier transform infrared (ATR-FTIR) spectra elucidated that rapamycin, RAPA (drug) was successfully embedded (encapsulated) onto NPs polymer matrix with **98.9 % encapsulation efficiency**.

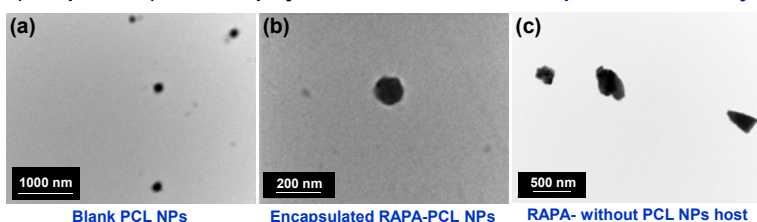


Fig. 6: Transmission electron microscopy (TEM) images of uniform spherical RAPA-encapsulated PCL NPs within particle size < 200 nm, polydispersity index (PDI) < 0.1 (highly monodispersed particles) produced at the optimum experimental conditions (refer to Table 1).

5. Conclusions

- Micro-engineered membrane system is shown to be convenient for production of **highly controllable size of NPs** that can be applied as a drug carrier with any substitution elements (eg: drug or nanofillers).
- The higher the **aqueous-to-organic volume ratio**, the higher the dilution factor of the polymer in the liquid phase and the lower the rate of particle growth after nucleation, resulting in smaller particle size.

Acknowledgements

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