Payload Loading and Release Rates from Mesoporous Silica Nanoparticles

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Overview

Mesoporous Silica Nanoparticles

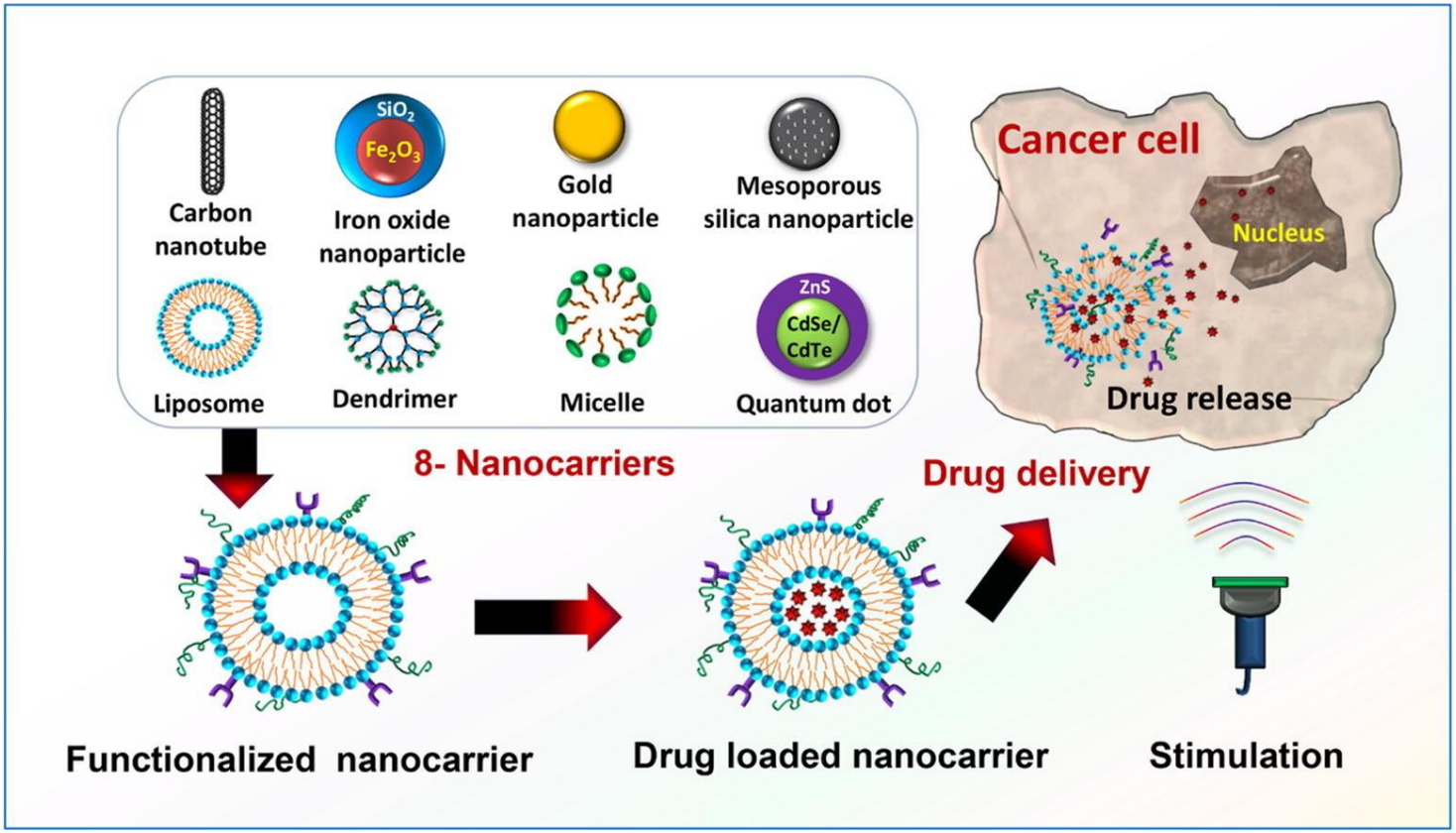
- Properties of MSNs
- Medical applications – Drug Carrier

What has been accomplished

- Synthesis of MSNs and surface-treatment
- Preliminary loading and release
- Loading -- Ionic charge
- release – pH

Conclusion and future research

MSN as a Drug-Delivery Vehicle



Example of drug delivery systems using host molecules comprised of various materials, including MSNs (Hossen *et. al*, 2019).

Properties of MSNs

- High surface area (>900 mg^2/g)
- Low density
- Large pore volume (>0.9 cm^2/g)
- Tunable pore size and structure
- Tunable particle size and shape

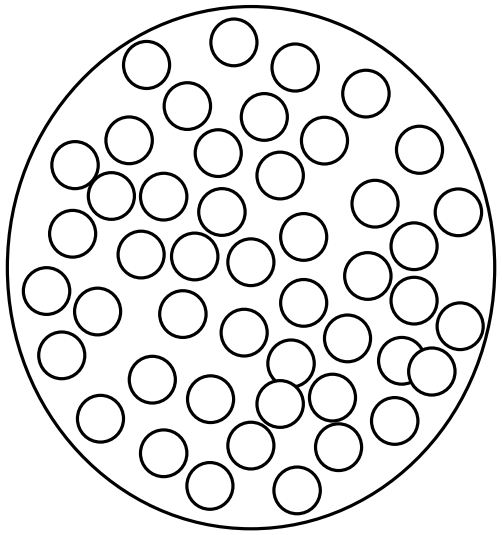
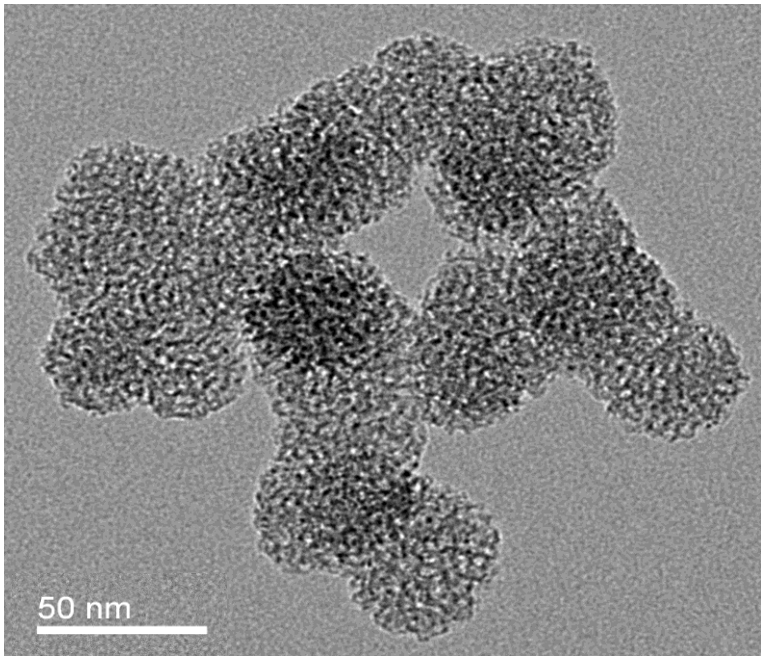


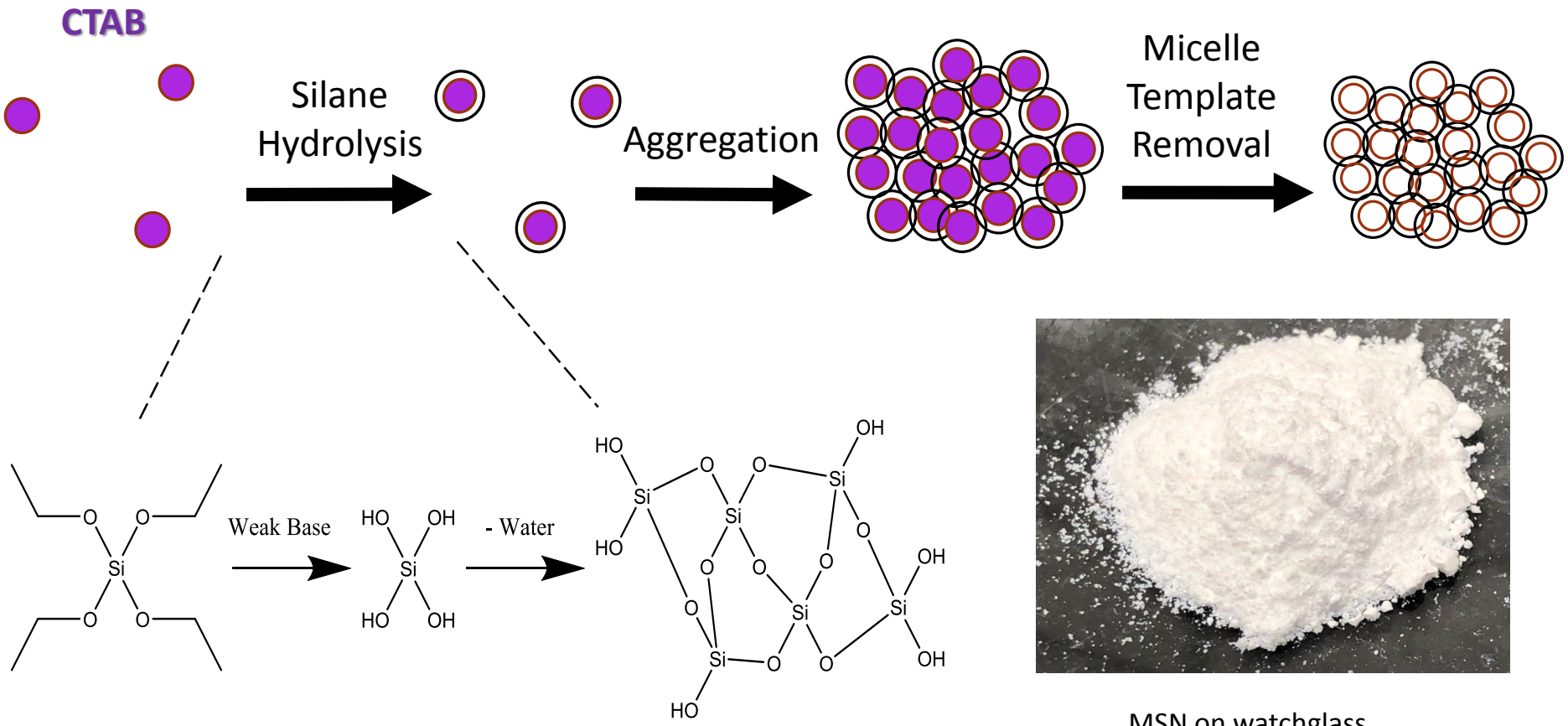
Diagram of wormhole-type MSN



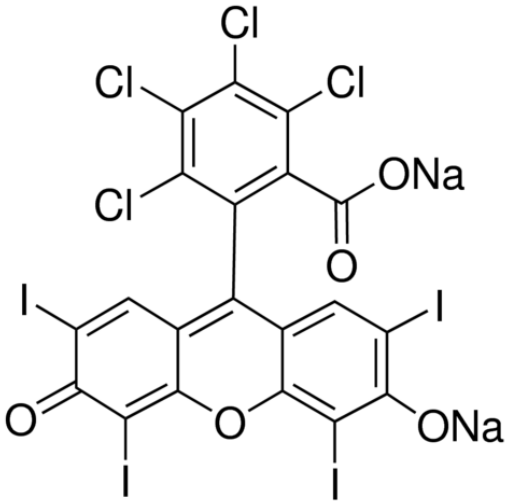
TEM image of wormhole type MSN with no modifications

What are the best conditions for payload loading and release from MSNs?

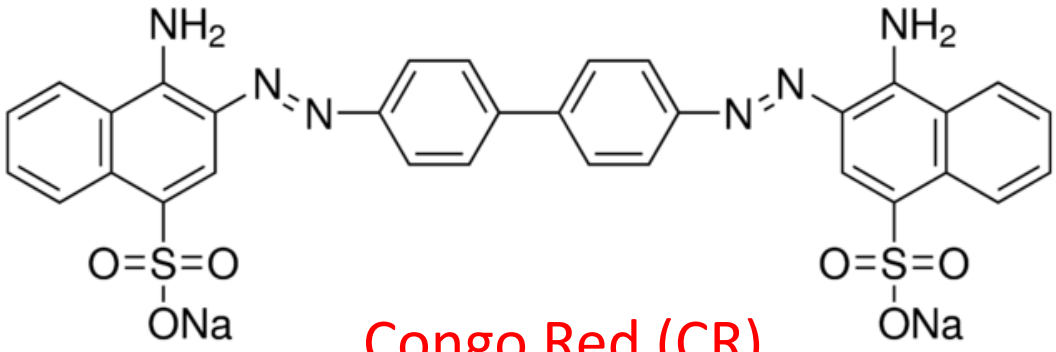
Synthesis of MSNs



MSN on watchglass



Rose Bengal (RB)

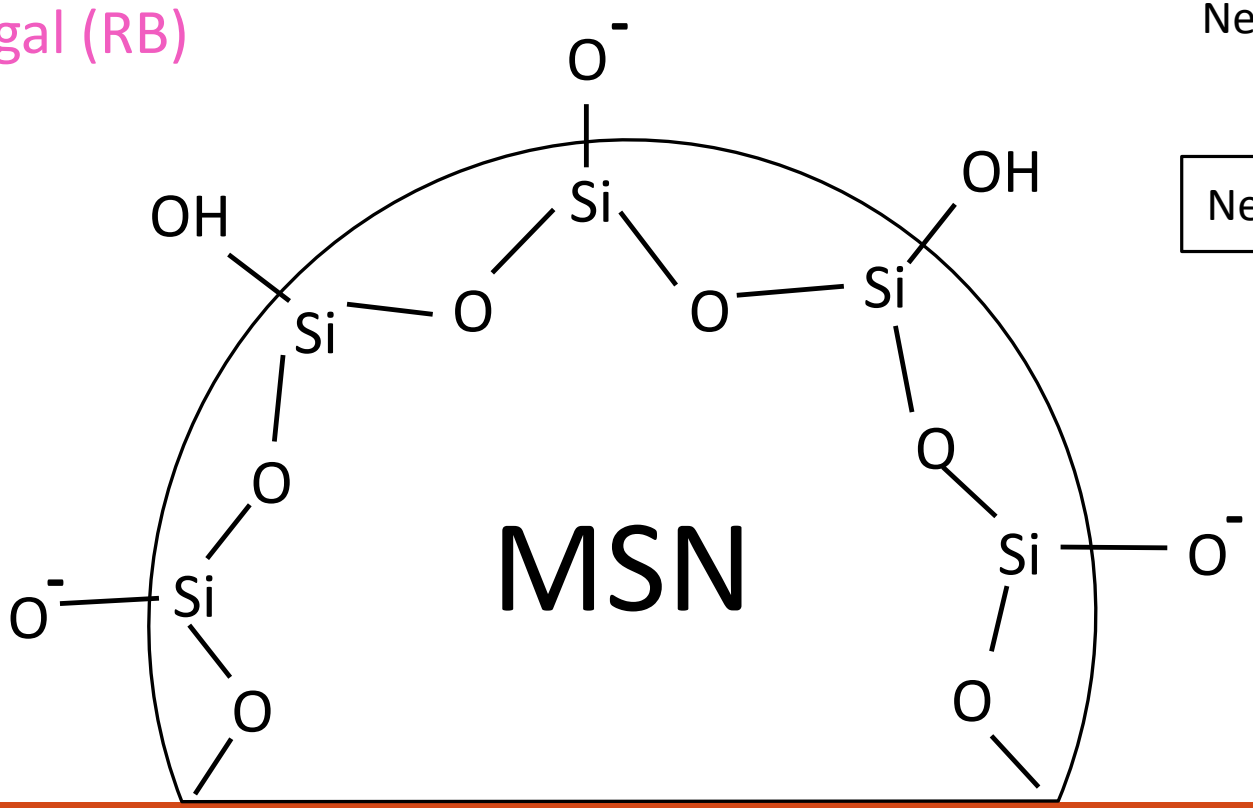


Congo Red (CR)

Negative Payload

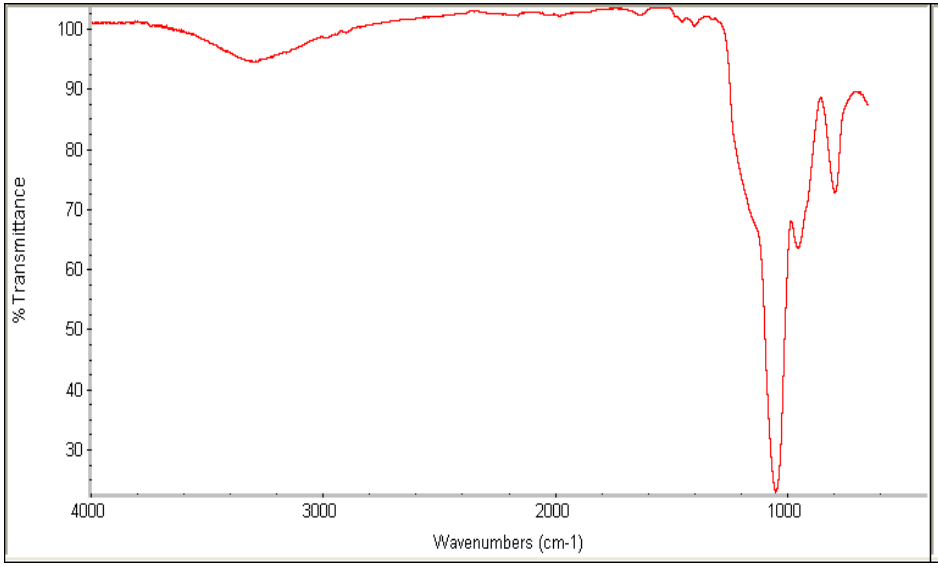
Repulsion

Negative Surface

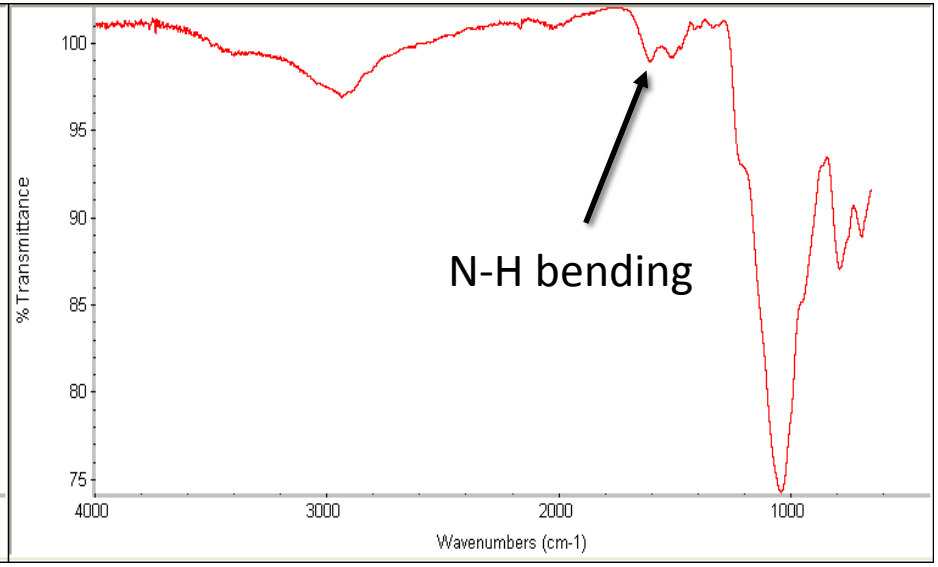


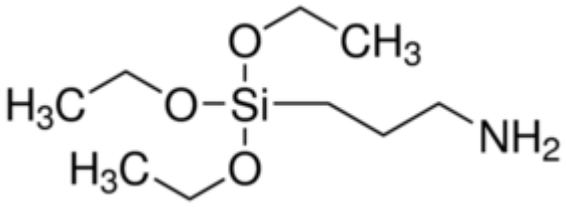
Amination of MSNs

Unmodified MSN



Amine-modified MSN





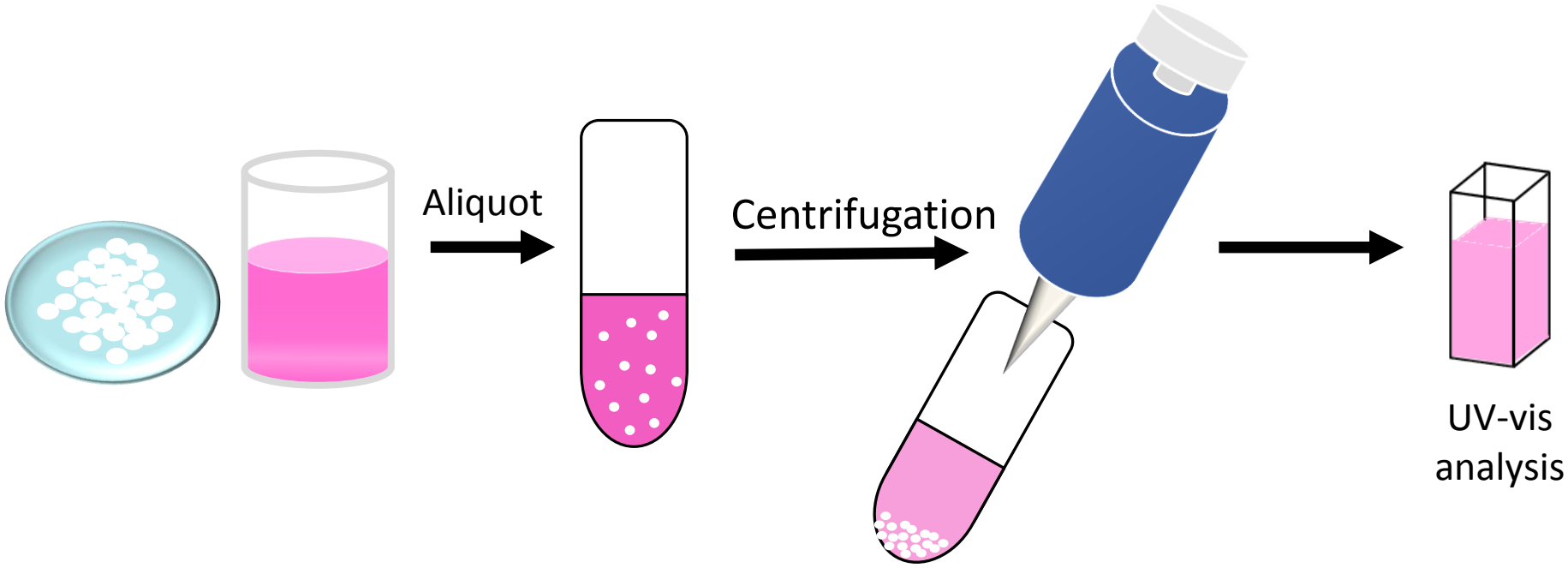
APTES

Negative Payload

Attraction

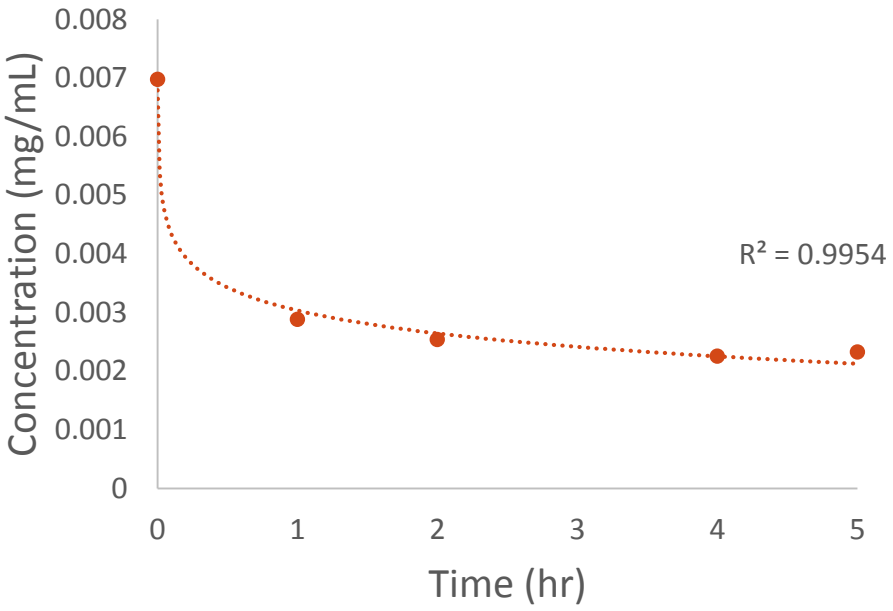
Positive Surface

Quantifying loading and release of payload from MSNs

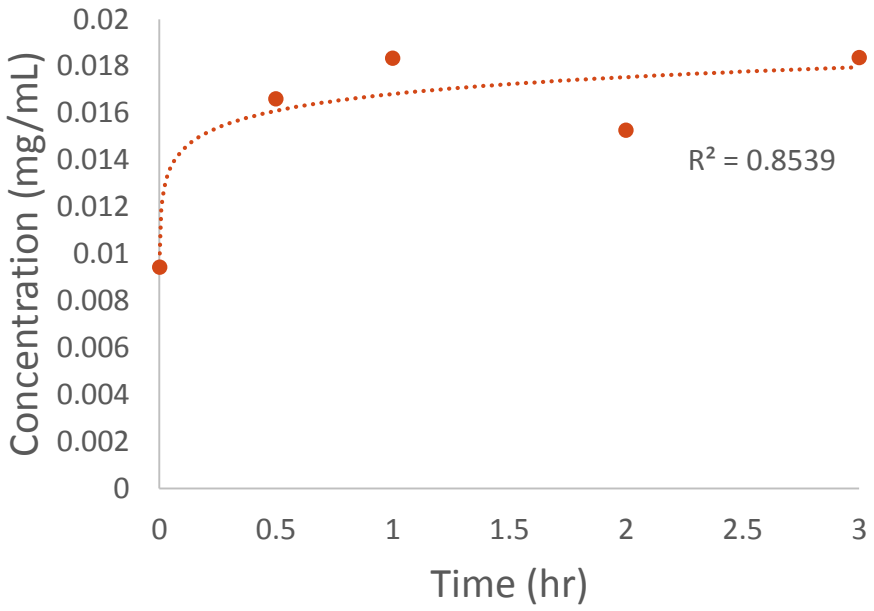


Loading and Release Study

Loading RB into aminated MSNs

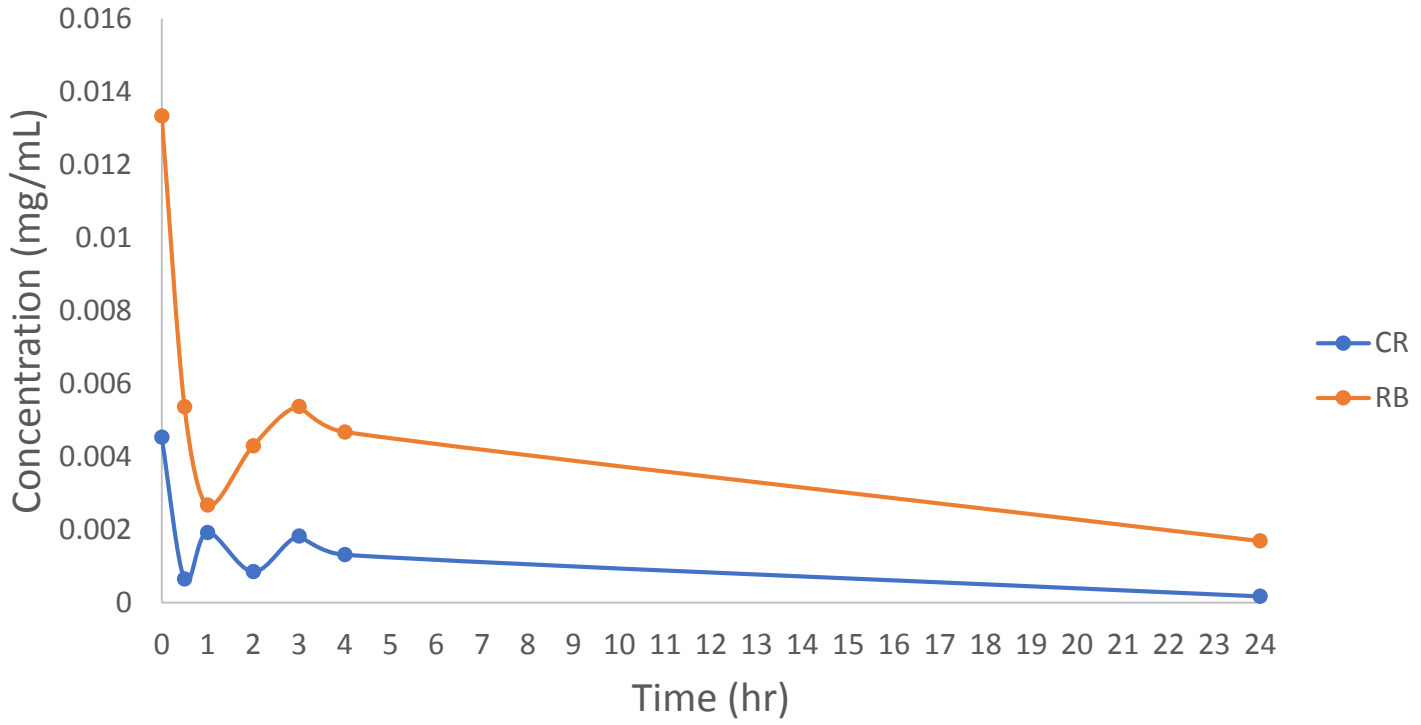


release RB from aminated MSNs



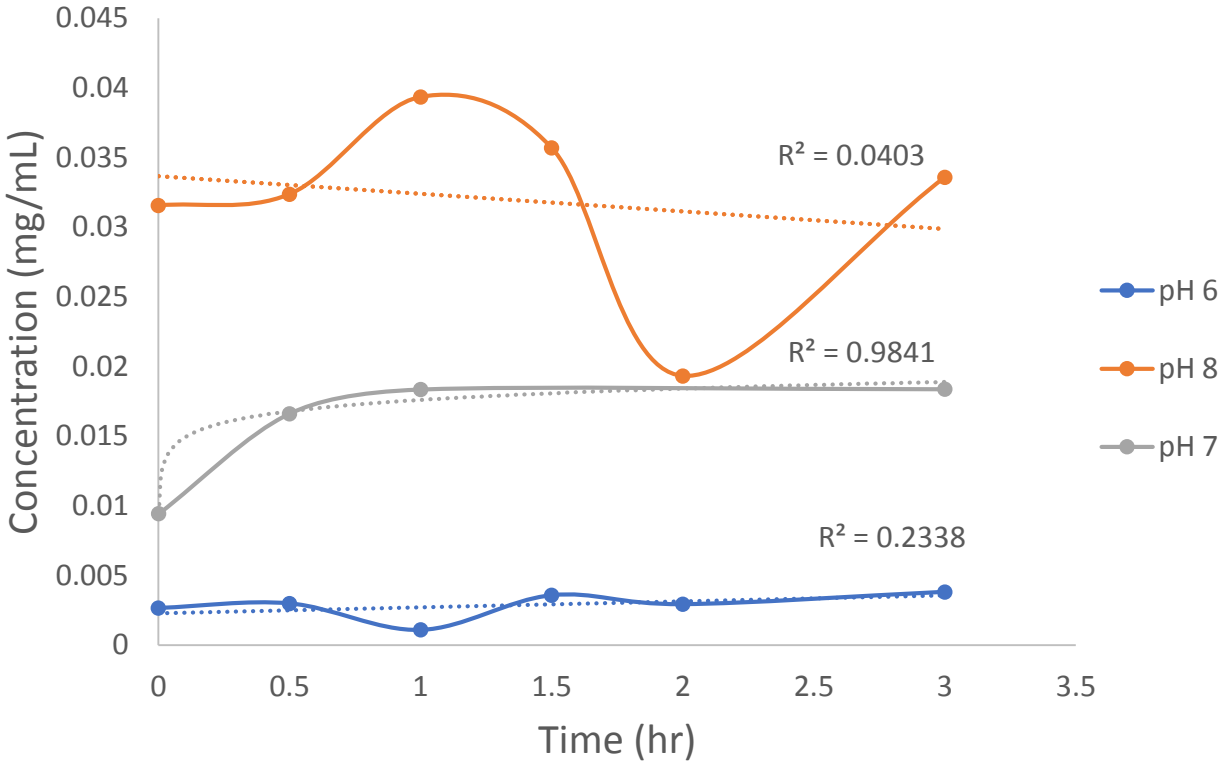
Studies used MSNs surface-treated with APTES and Rose Bengal (RB) as the payload. Results suggested logarithmic decay and growth, respectively, as originally hypothesized.

Loading MSNs with dyes containing various ionic charge



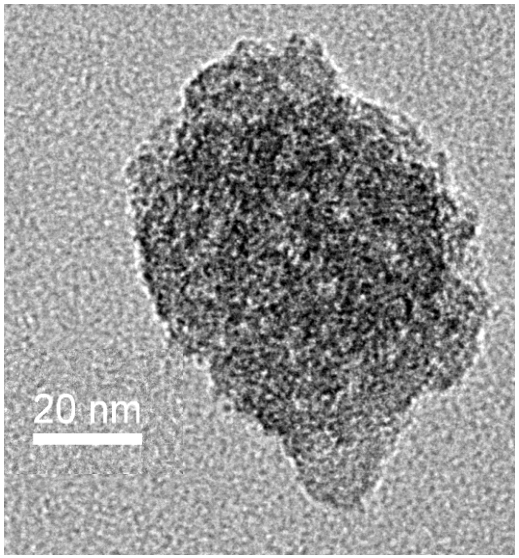
Study was performed using Rose Bengal and Congo red, two dyes with ionic charge of -1 and -2, respectively.

Release study with pH

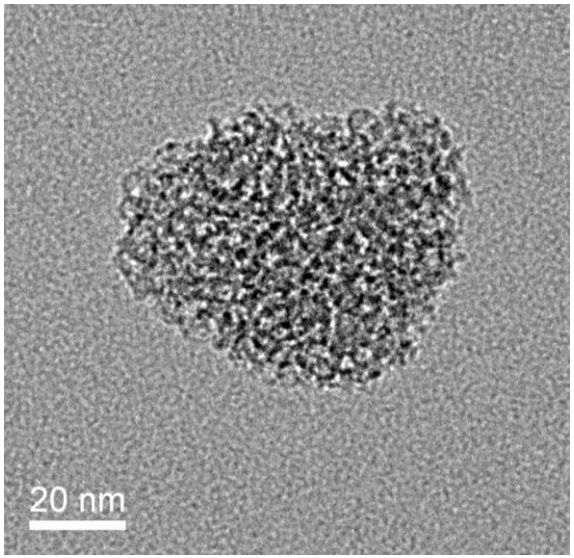


Release was performed using water created through acidic (pH 6) and basic (pH 8) conditions. Accompanying images shows resultant solution after three hours.

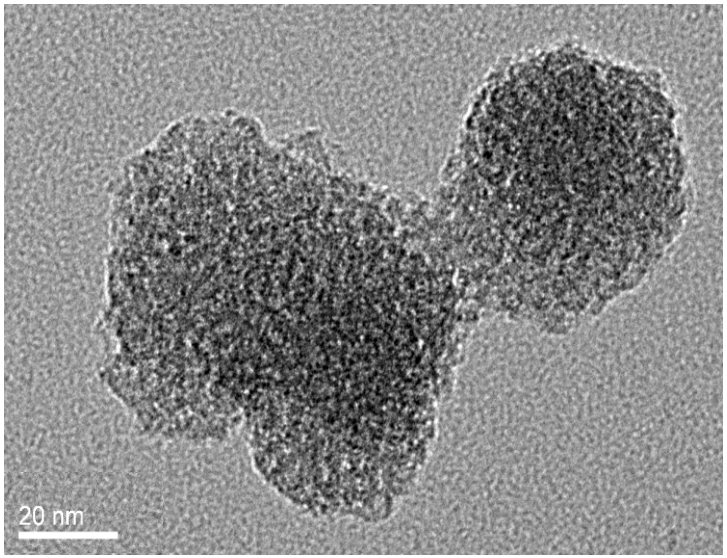
Comparison of regular versus pH treated MSNs (TEM)



pH 6 (Acidic)



pH 7 (Neutral)



pH 8 (Basic)

MSNs unloaded in acidic, neutral, and basic conditions after 3 hr. Pore structure and size was maintained.

Conclusion & Next Steps

Information gained from this project:

- 3 hours maximum
- Understanding electrostatic attraction between carrier and payload
- Neutral pH/analyze release profiles

Future Research:

- Validate Findings – ICPMS or thermogravimetric analysis
- Nanocores for controlled release of payload using MSNs
- Manipulate other factors
  - Surface treatments, different payloads, capping

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References

[1] Slowing, I. I.; Vivero-Escoto, J. L.; Wu, C.-W.; Lin, V. S.-Y. Mesoporous Silica Nanoparticles as Controlled Release Drug Delivery and Gene Transfection Carriers. Advanced Drug Delivery Reviews2008, 60, 1278–1288.

[2] Lin, Y.-S.; Hurley, K. R.; Haynes, C. L. Critical Considerations in the Biomedical Use of Mesoporous Silica Nanoparticles. The Journal of Physical Chemistry Letters2012, 3(3), 364–374.

[3] Möller, K.; Bein, T. Degradable Drug Carriers: Vanishing Mesoporous Silica Nanoparticles. *Chemistry of Materials* **2019**, *31*(12), 4364–4378.

Image Citation

[1] Hossen, S.; Hossain, M. K.; Basher, M.; Mia, M.; Rahman, M.; Uddin, M. J. Smart Nanocarrier- Based Drug Delivery Systems for Cancer Therapy and Toxicity Studies: A Review. *Journal of Advanced Research* **2019**, *15*, 1–18.