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Hybrid nanocomposite beads of Areca husk derived cellulose fibre, sodium alginate and green synthesized TiO_2 for controlled release of bioactive agents

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INTRODUCTION & AIM

Sustainable Nanocomposite Beads for Agriculture

- Growing demand for eco-friendly fertilizers and pesticides in modern agriculture.
- Controlled release systems enhance nutrient uptake & reduce environmental losses.
- Natural polymers (e.g., cellulose, alginate) are biodegradable , non-toxic & cost-effective.
- Nanomaterials improve stability, photocatalytic activity and efficiency in delivering bioactive agents.

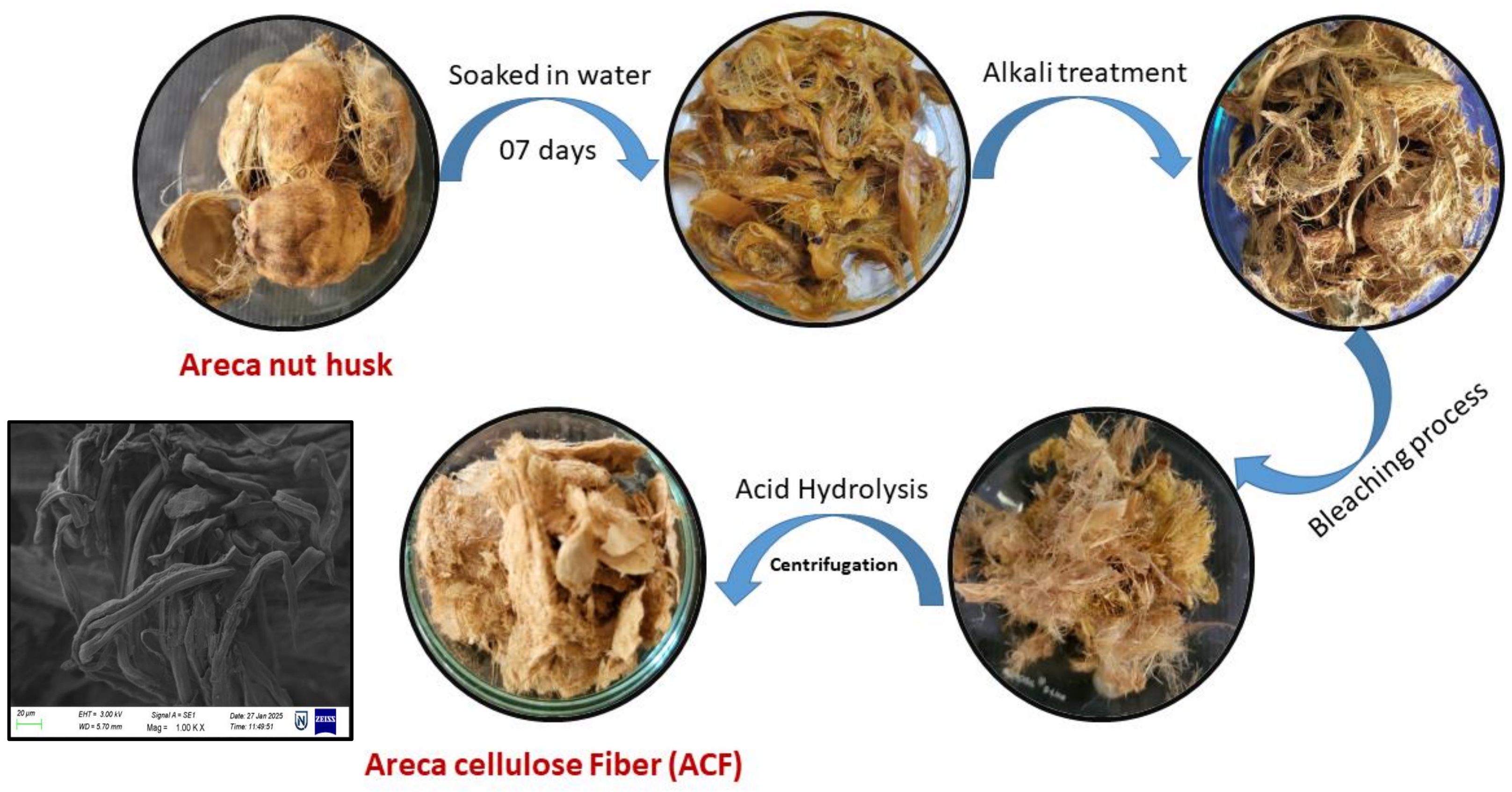
Why Sustainable Agriculture Matters?

- Essential for **future food security**: balances productivity with environmental protection.
- Promotes a **circular bio-economy**: converts agricultural waste into value-added materials.
- Supports **soil health, water conservation**, and **biodiversity protection**.

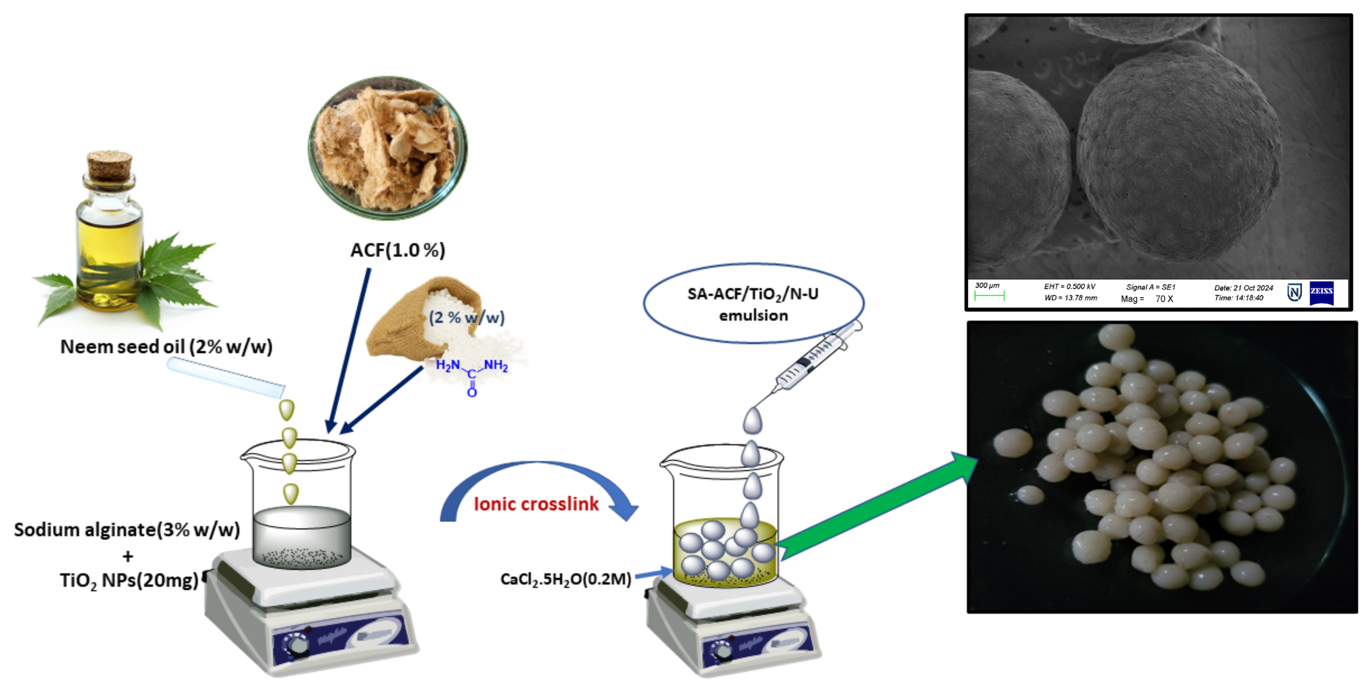
- In this study, hybrid nanocomposite beads were prepared using areca husk–derived cellulose(ACF), sodium alginate(SA) polysaccharide, and TiO_2 nanoparticles (TiO_2 NPs).
- The synthesized nanocomposite beads provide a dual-release system for urea and neem seed oil (NSO), ensuring that both inputs are supplied to plants in a controlled manner to enhance growth and yield.
- By integrating natural biopolymers with nanotechnology, this system addresses the limitations of conventional fertilization and pest-management practices, offering a more efficient and environmentally sustainable alternative.

Effects of Conventional nutrients and Pesticides
- Leaching
- Excess residue
- Toxic

METHOD

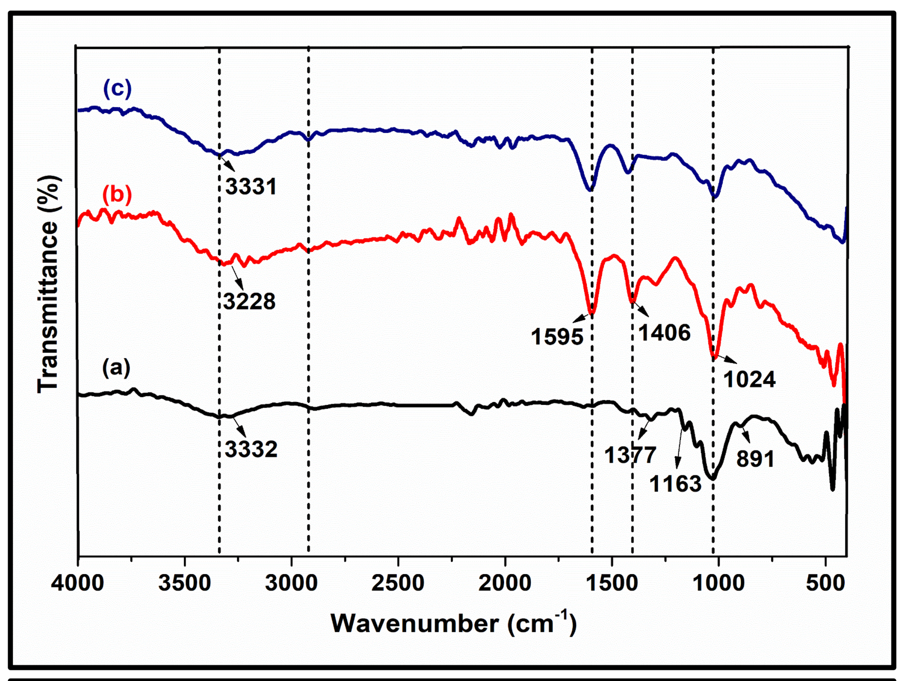


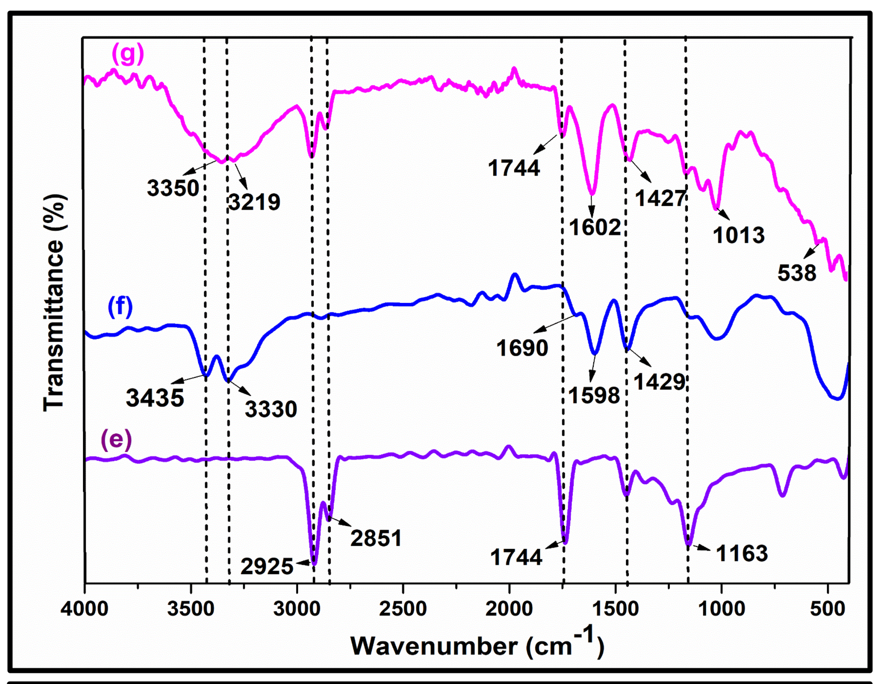
Extraction of cellulose fiber from area husk (ACF)

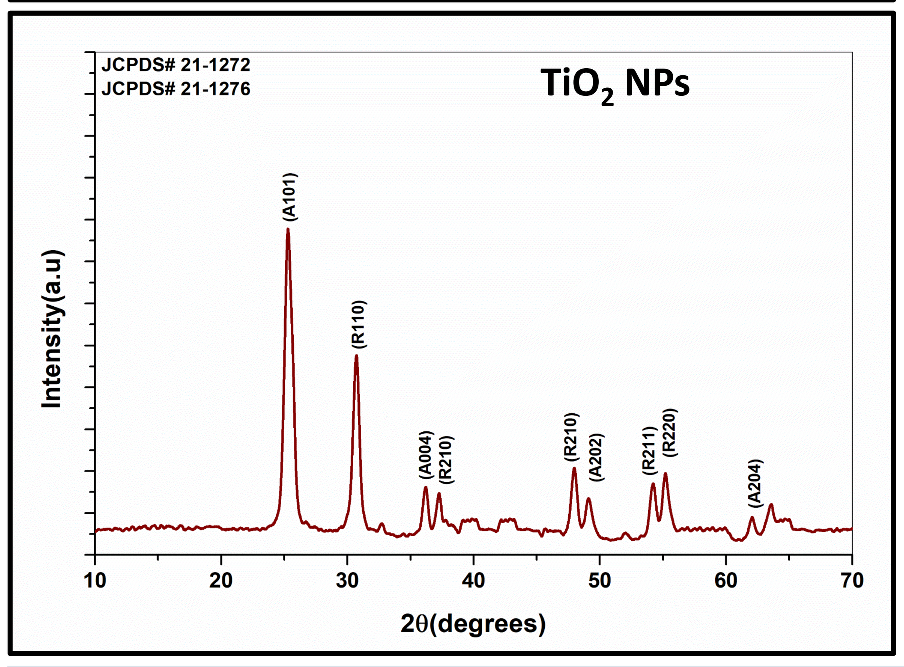


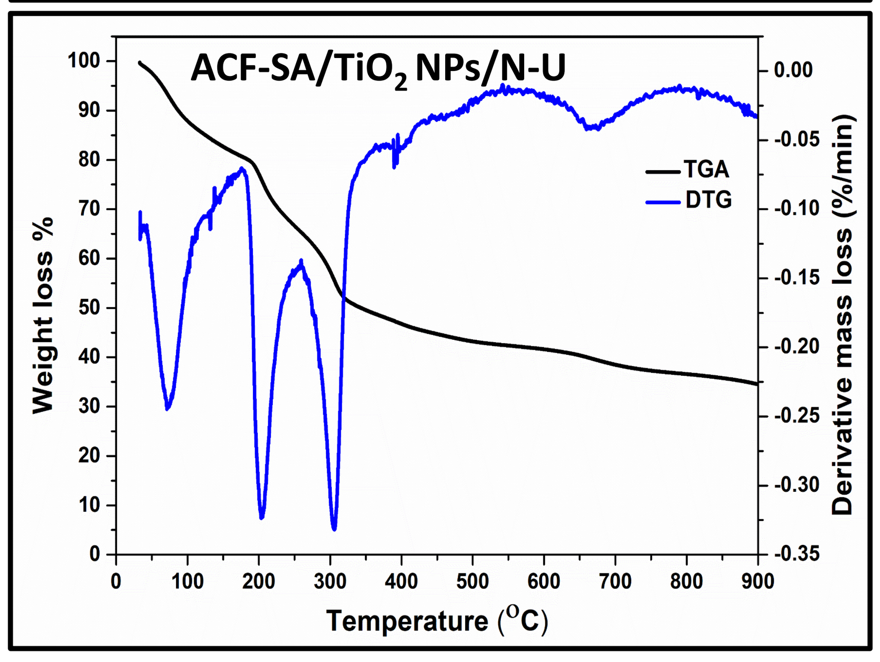
Preparation of hybrid nanocomposite beads

RESULTS & DISCUSSION



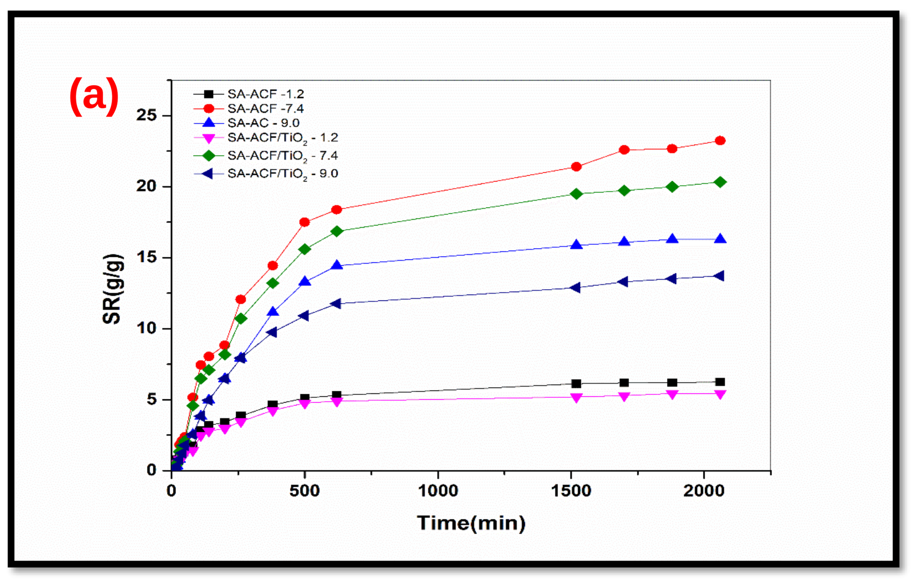


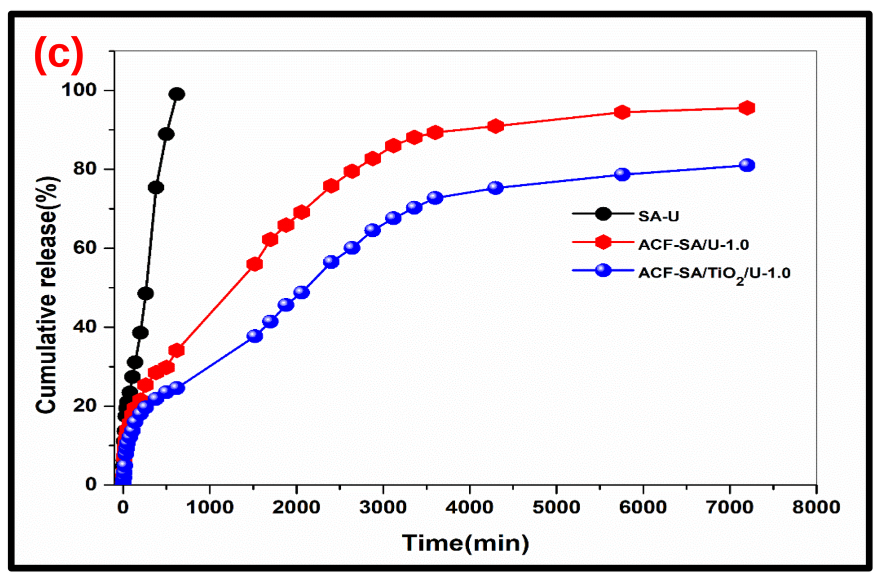


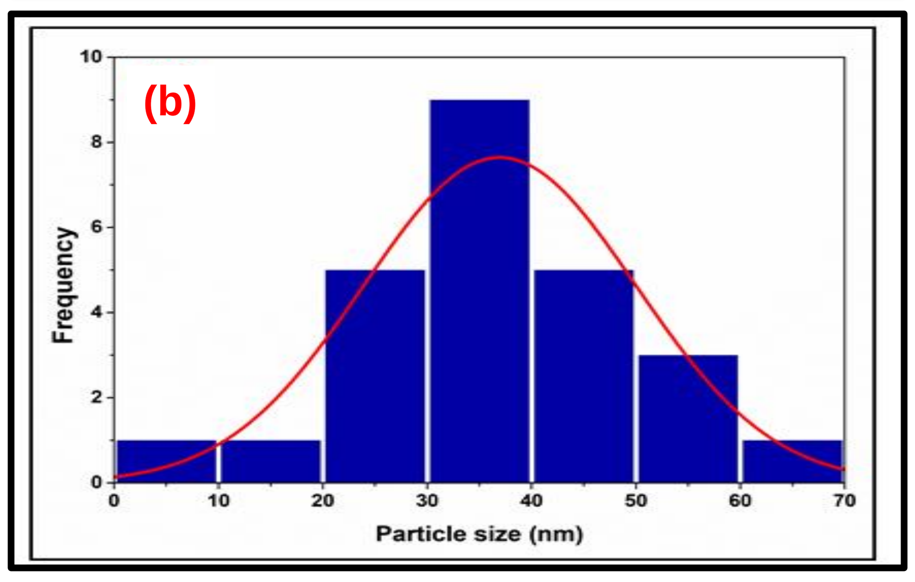


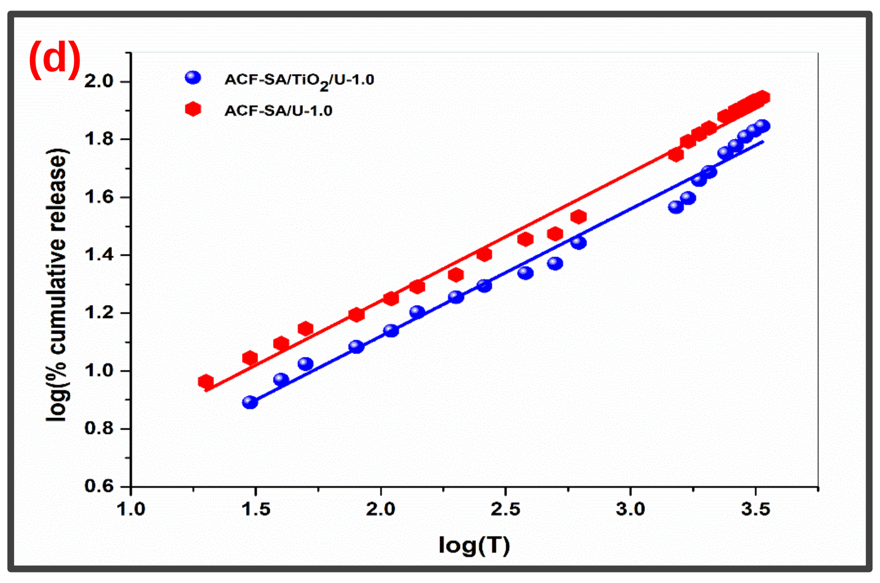
(a) ACF (b) SA (c) ACF-SA (e) NSO (f) Urea (g) ACF-SA/TiO_2 NPs/N-U

CONCLUSION









(a) Swelling behavior of beads at different pH conditions (b) Particle size distribution of TiO_2 NPs (c) Urea release profile (d) Korsmeyer-Peppas model for for urea release

- Successfully fabricated eco-friendly hybrid nanocomposite beads using bio- derived areca husk cellulose and sodium alginate.
- Titanium dioxide nanoparticles synthesized via a green method using neem leaf extract.
- Beads formed through a simple ionic crosslinking process using $CaCl_2$.
- Urea as N-fertilizer showed highest EE (96.58%) and controlled release of 95.24%.
- Release kinetics followed Korsmeyer-Peppas model.
- n<0.5 indicates Fickian type of diffusion.
- NSO + urea gives synergistic effect.

FUTURE WORK / REFERENCES

- Demonstrates a *sustainable alternative* to conventional fertilizers and pesticides, promoting reduced nutrient use and lower environmental impact.
- Future efforts should focus on **scaling up the production** of these sustainable beads and investigating their real timeapplication in **stimuli-responsive release** for targeted biopesticide or nutrient delivery.

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- Kennedy, J. P. K.; Muthuramalingam, J. B.; Balasubramanian, V. K.; Balakrishnan, M.; Murugan, K.; Ponnuchamy, K. Controlled Release of Urea Using Negatively Charged Polysaccharides. *Polym. Adv. Technol.***2024**, *35*, e6508..

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