OP-244 [Beekeeping Technology and Quality]

From Hive to Biomedical Application: Bee Pollen-Derived Biocompatible Sporopollenin Microcapsules for Gastrointestinal Drug Targeting

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Bee pollen is a valuable nutritional and functional food with various health benefits. It also serves as a resource for fabricating pollen-based microcapsules, fostering innovations in biomedical applications, food technology, and environmental sustainability. However, the transformation of bee pollen into a drug mini-cargo carrier remains insufficiently described. Herein, we outline this process, demonstrating its potential for drug delivery systems. Bee pollen pellets were collected and sorted by color, with palynological analysis confirming up to 97% purity for species including Echium sp., Jasione sp., Papaver sp., Amaranthaceae, and Helianthemum sp. A chemical treatment removed the pollen's inner content and intine layer, yielding sporopollenin microcapsules (SMCs) composed solely of the exine shell. Protein analysis revealed a reduction in potential allergenic proteins from 14–33% to 2–7%. Advanced microscopic and particle size analyses confirmed the hollow, uniform structure (15–24 µm) of the SMCs. Fourier-transform infrared analysis showed a structural model in which SMCs consist of aliphatic chains cross-linked with phenylpropanoid derivatives via ester and acetal bonds while thermal analysis showed thermal decomposition up to 457°C. Given their inherent hydrophobicity, The surface chemistry of SMCs was treated using UV-irradiation, rendering them super hydrophilic. Cell adhesion assays revealed increased adherence of UV-modified SMCs to Caco-2 cell lines, with no cytotoxicity in normal Vero cells. As a proof of concept for site-specific drug delivery, Helianthemum sp. type SMCs were loaded with 5-Fluorouracil (5-FU) and coated with 5% and 15% Eudragit to prevent premature release. A 76% encapsulation efficiency was achieved via vacuum-loading. Different coating concentrations were adjusted for controlled and sustained release of the 5-FU in specific environments in the gastrointestinal tract.

These findings highlight the potential of SMCs derived from bee pollen as a safe, efficient, and tunable platform for targeted drug delivery in biomedical applications, enhancing the value of bee pollen beyond its nutritional recognition, and therefore add a source of additional income for beekeepers.

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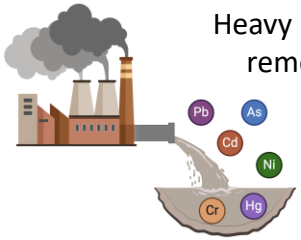
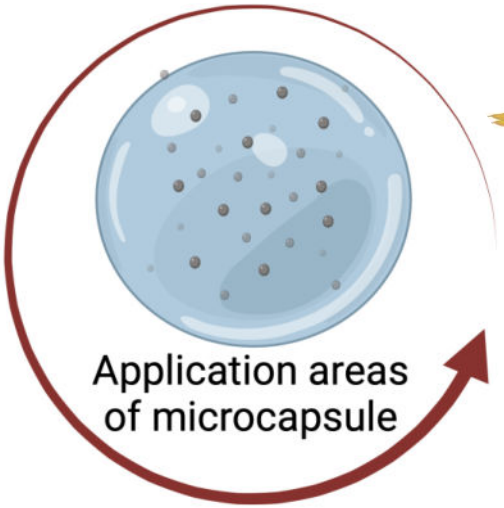
ipb INSTITUTO POLITÉCNICO DE BRAGANÇA
CIMO Centro de Investigação de Montanha
U.PORTO FACULDADE DE CIÊNCIAS UNIVERSIDADE DO PORTO
LAQV requimte LABORATÓRIO ASSOCIADO PARA A QUÍMICA VERDE
CINTESIS Health. Research.
fct Fundação para a Ciência e a Tecnologia
REPÚBLICA PORTUGUESA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

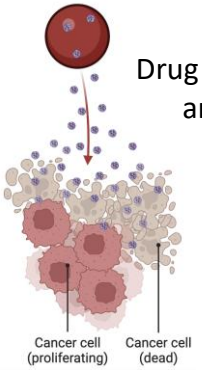
Relevance of Research on Microcarrier Technology



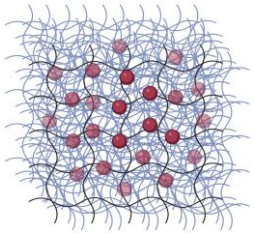
Heavy metals removal

Food active preservation





Drug encapsulation and delivery



Textile applications

Polymeric

Alginate
Chitosan
Cellulose

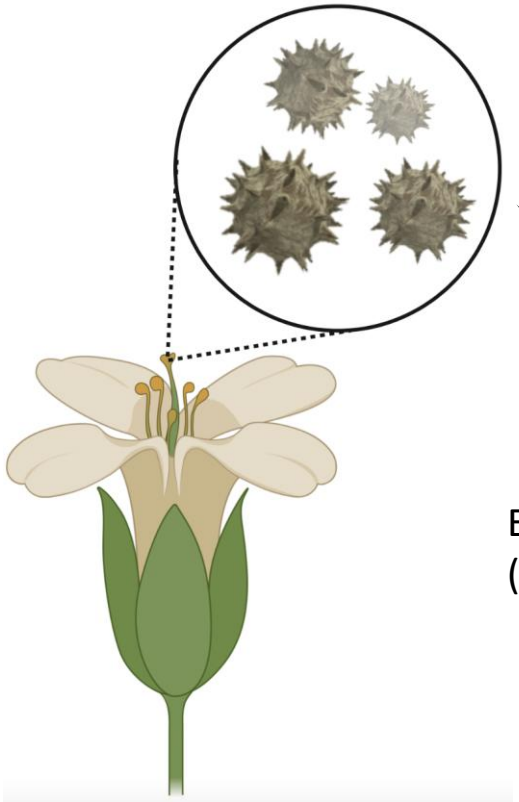
Poly(ethylene glycol)
Polyvinyl alcohol
Polyurethane

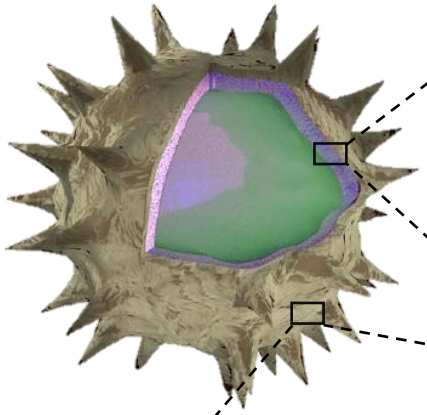
Inorganic

Mesoporous silica
Metallic and
Magnetic particles

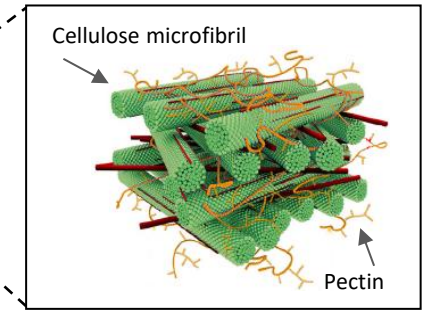
Organic-inorganic hybrid materials

Relevance of Research on Pollen

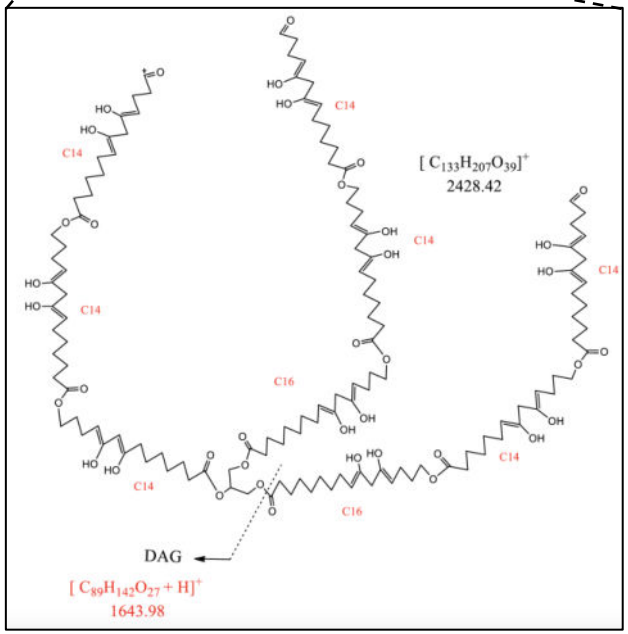




Intine-inner layer



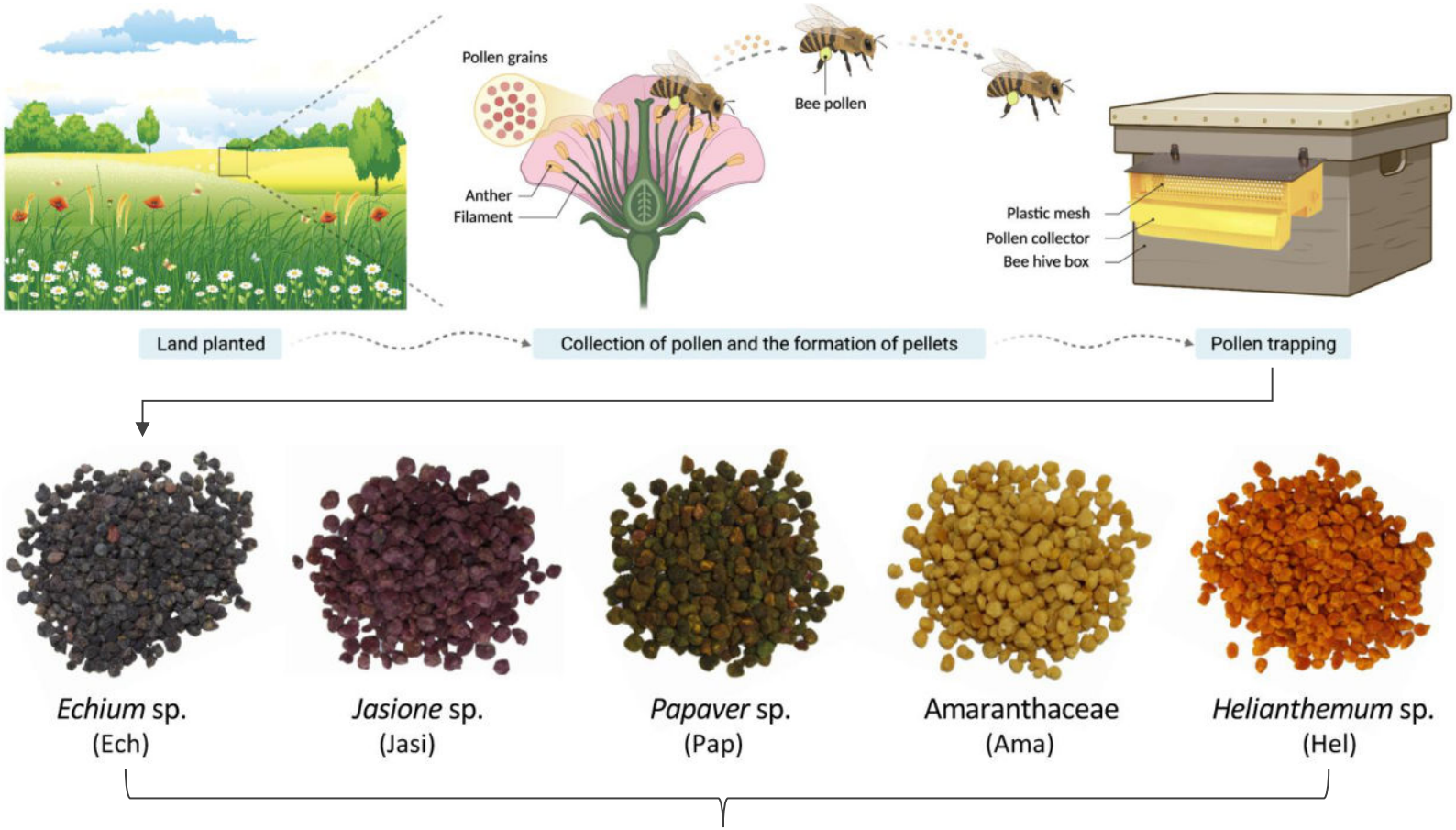
Exine-outer layer
(sporopollenin polymer)



- Pollen biology
- Material science
- Food science
- Pharmaceutical applications

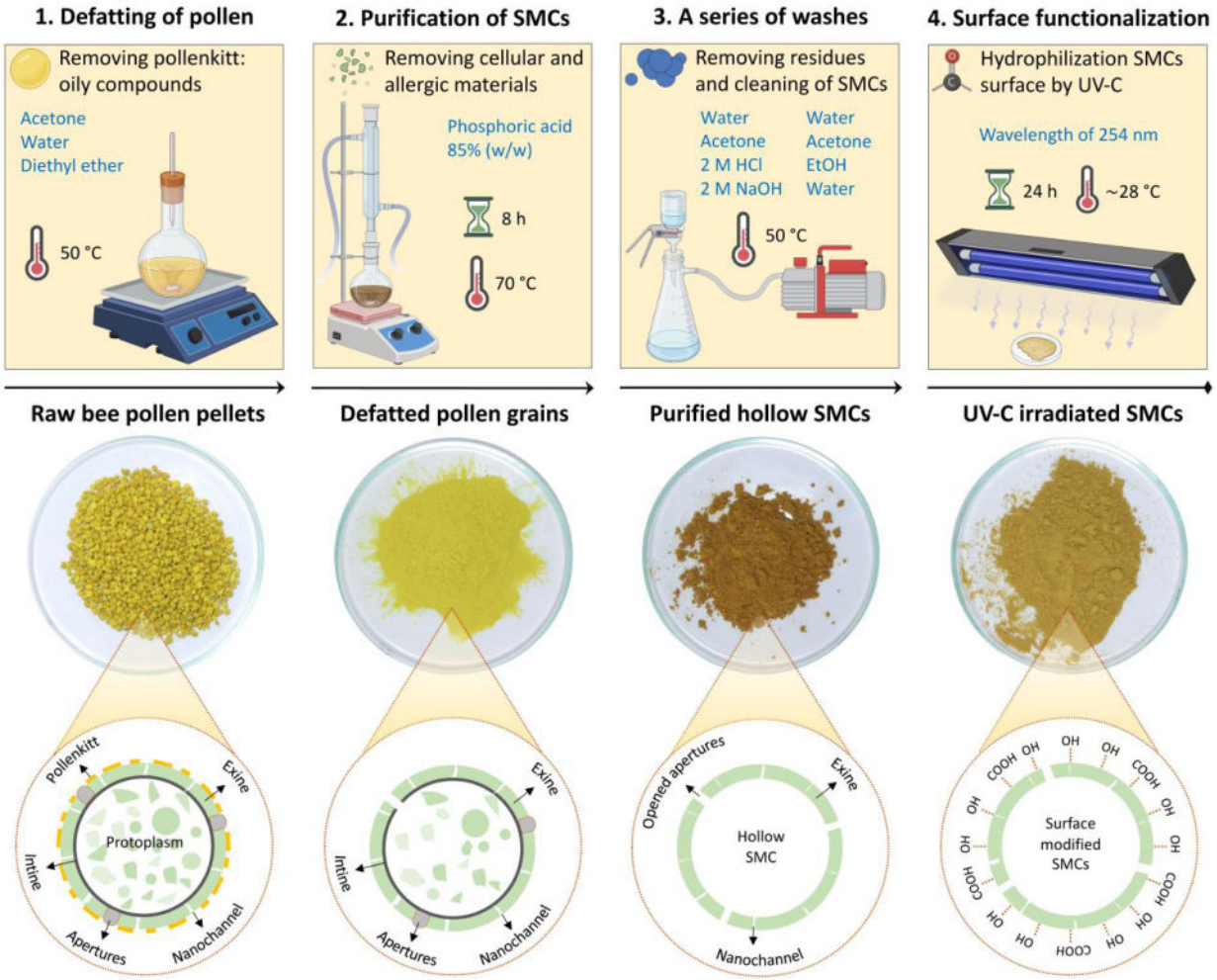
Experimental Approach

- Collecting bee pollen pellets and sorting them according to their main colors.



Experimental Approach

- Purification of exine-layered pollen grains from bee pollen pellets



Total protein content

SEM

LDPS

FTIR

TGA

Water contact angle

AFM

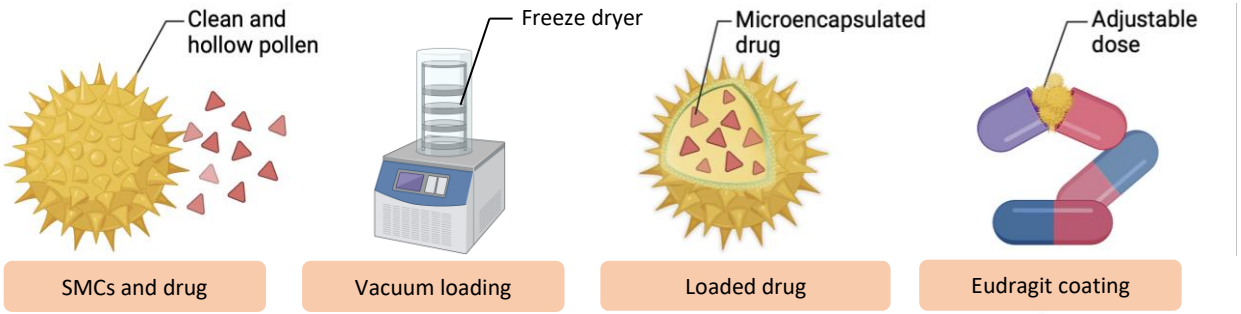
CLSM

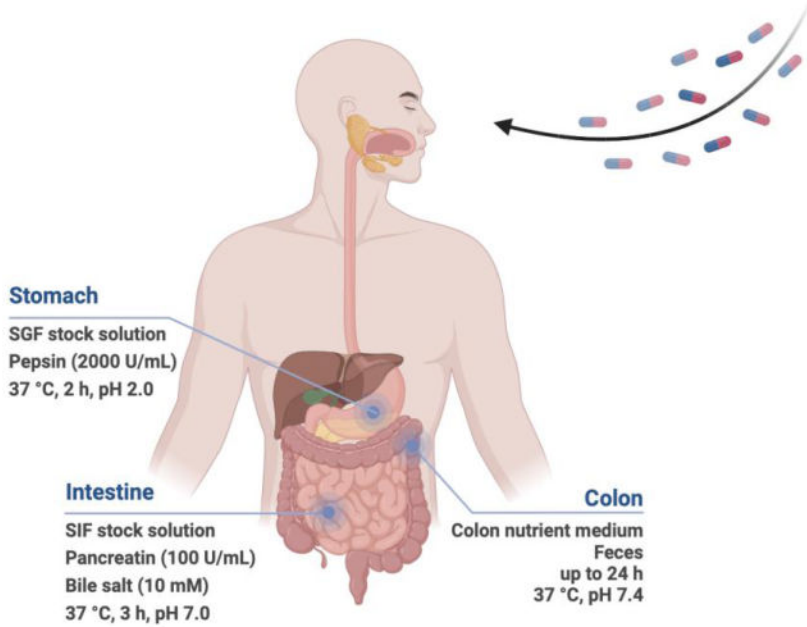
Biocompatibility on the Vero cell line

Adhesion on the Caco-2 cell line

Experimental Approach

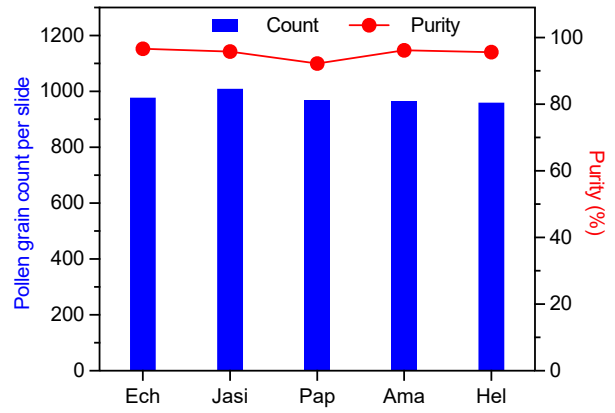
- Loading of 5-Fluorouracil (5-FU) drug, coating with polymer and releasing the drug in the gastrointestinal tract

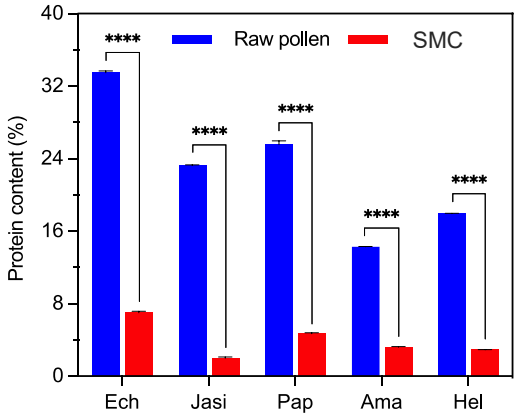


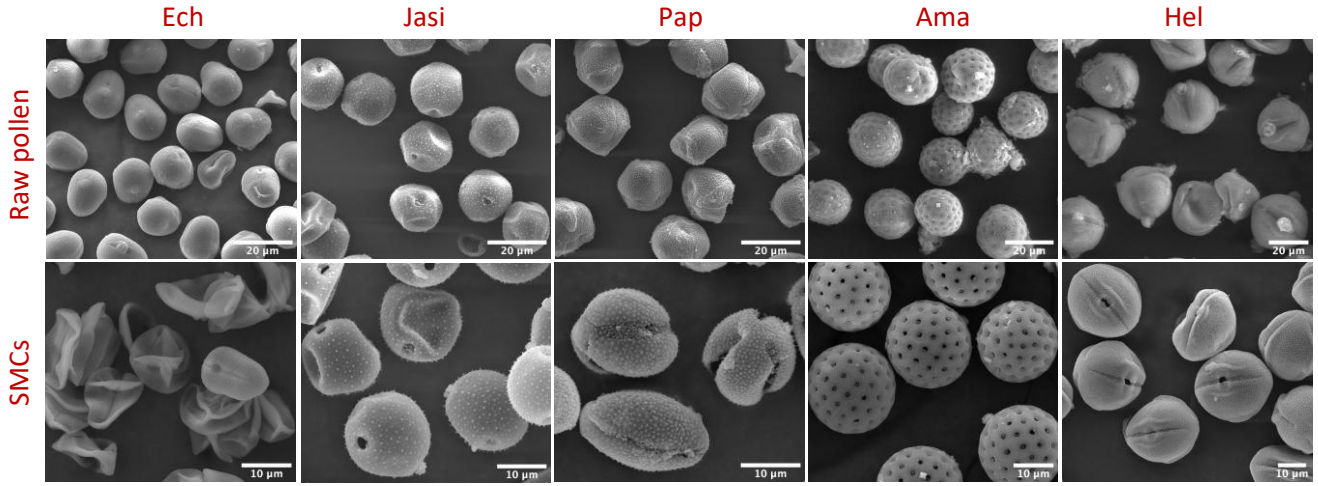


Key Findings

- Purity ratios of the bee pollen were obtained from the palynological analysis and the protein content of bee pollen and exine-layered pollen.



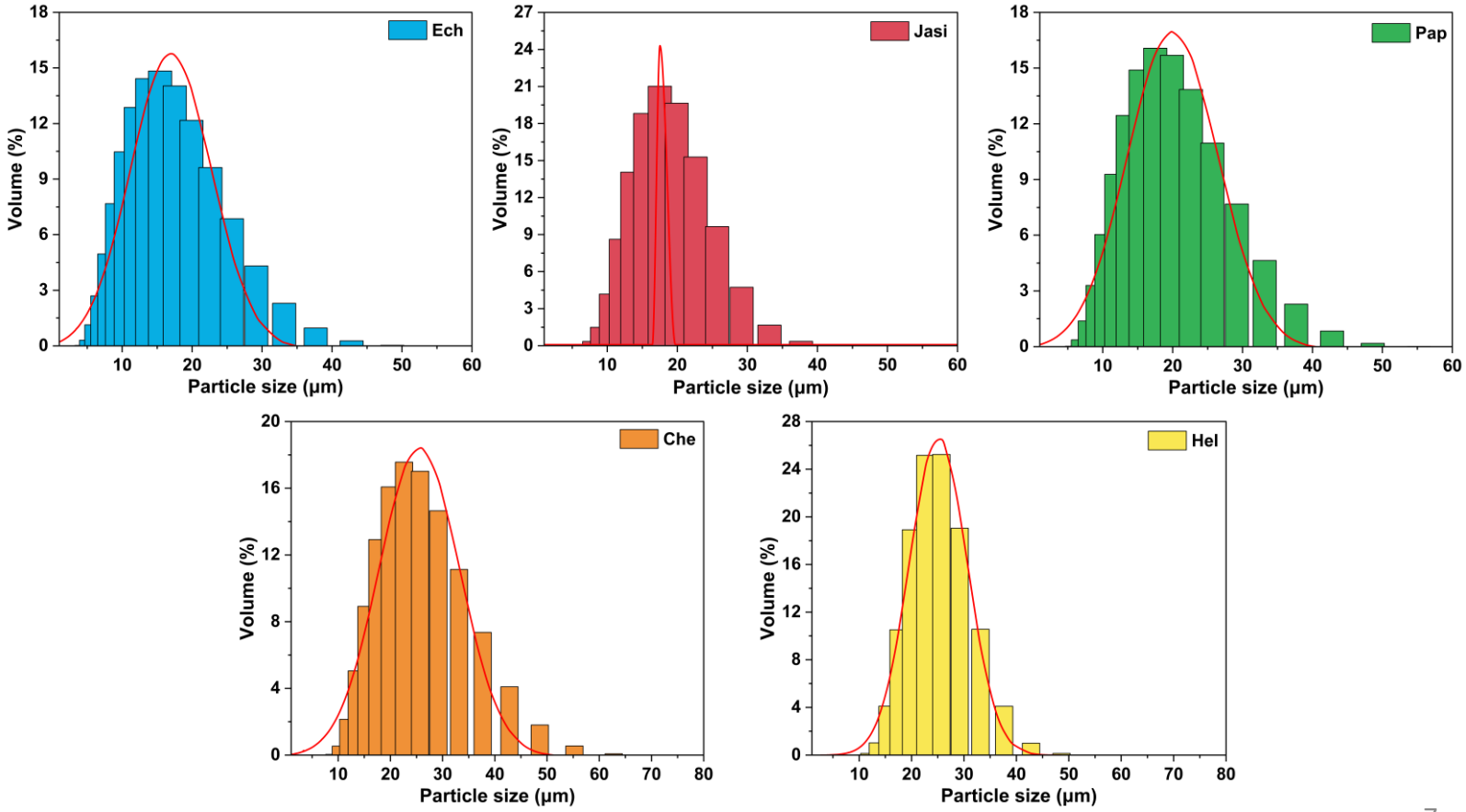




The data are presented as the average of three measurements with standard deviation (n = 3).

Key Findings

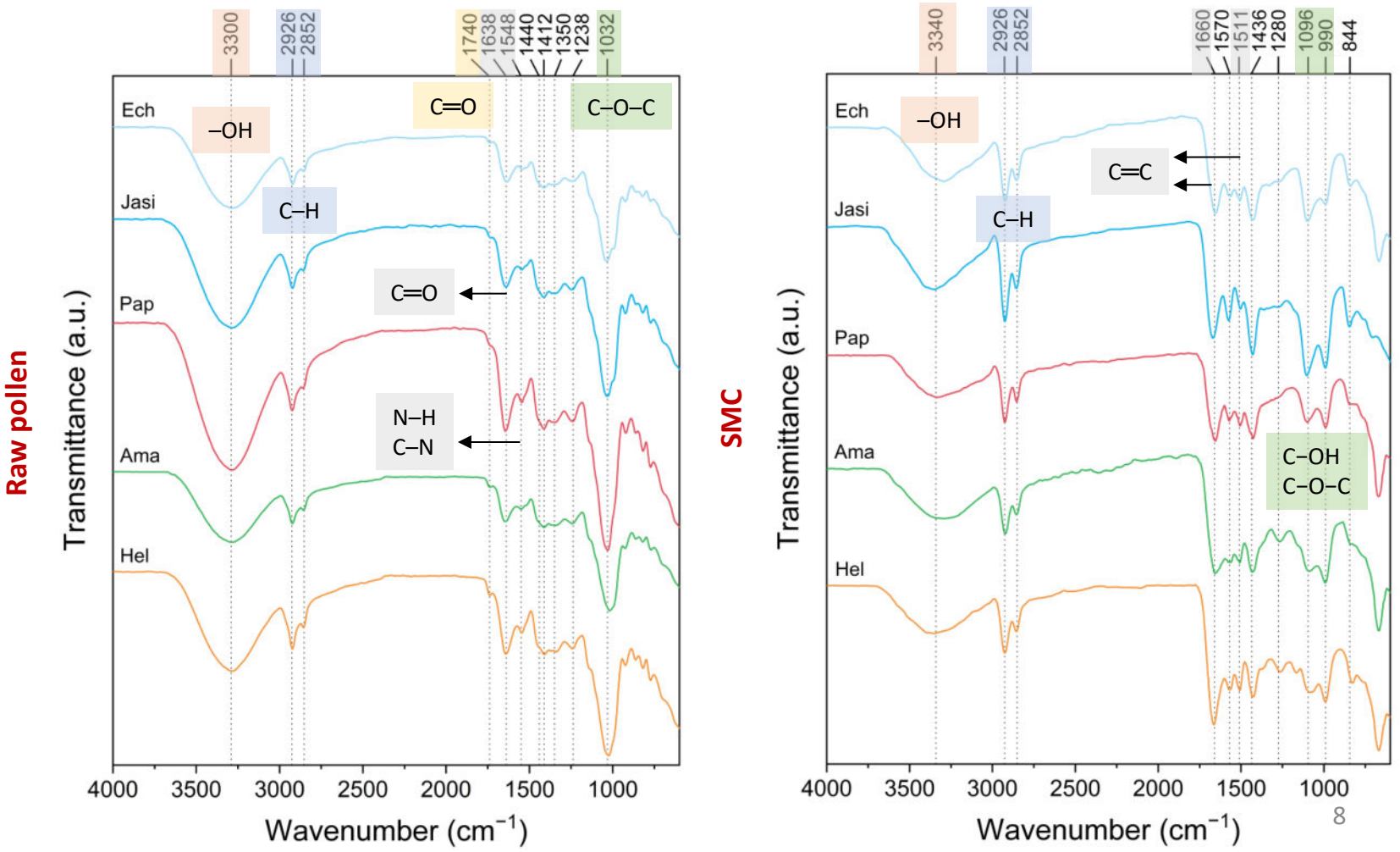
- The laser diffraction data validate the monodispersity achieved by color-based pollen separation. The mean spherical diameters of SMCs were 15.1 ± 0.1 µm (Ech), 17.7 ± 0.0 µm (Jasi),18.1 ± 0.0 µm (Pap), 23.5 ± 0.1 µm (Ama), and 24.1 ± 0.1 µm(Hel).



The data are presented as the average of five measurements with standard deviation (n = 5).

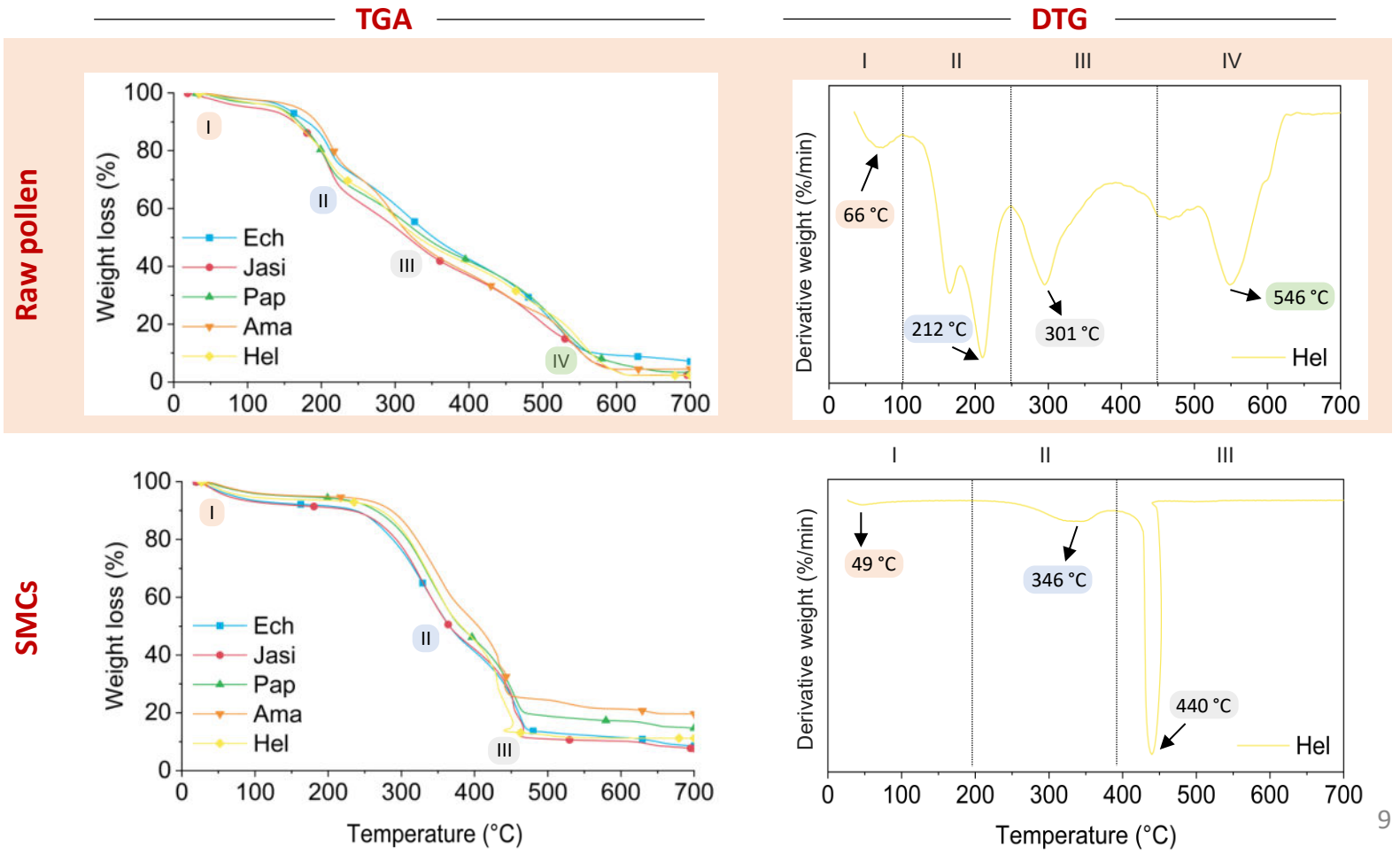
Key Findings

- FTIR points out distinct aliphatic and aromatic domains in the chemical structure of sporopollenin from various plant sources



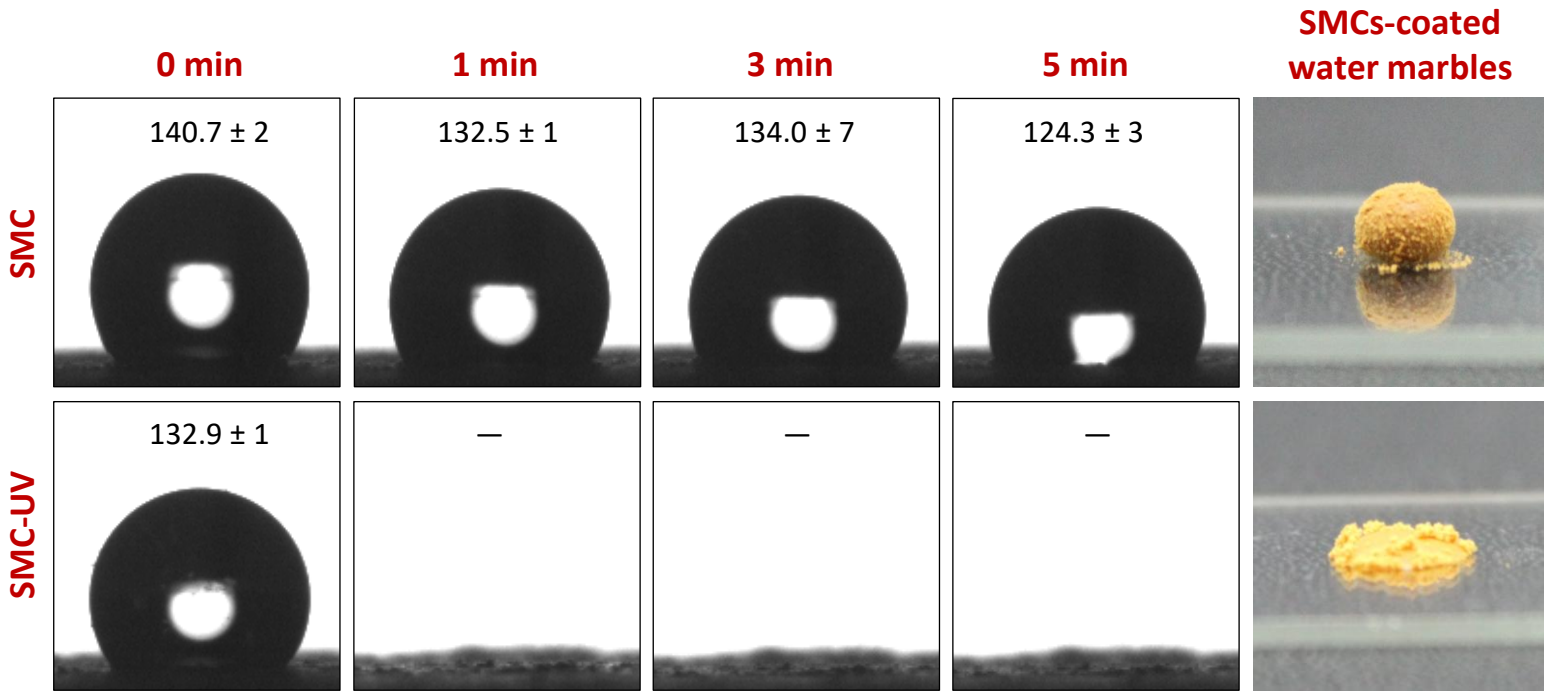
Key Findings

- The raw pollens exhibited a maximum thermal degradation ranging from 518 to 548 °C, while exines of these pollen demonstrated a lower temperature range of 436 – 457 °C.



Key Findings

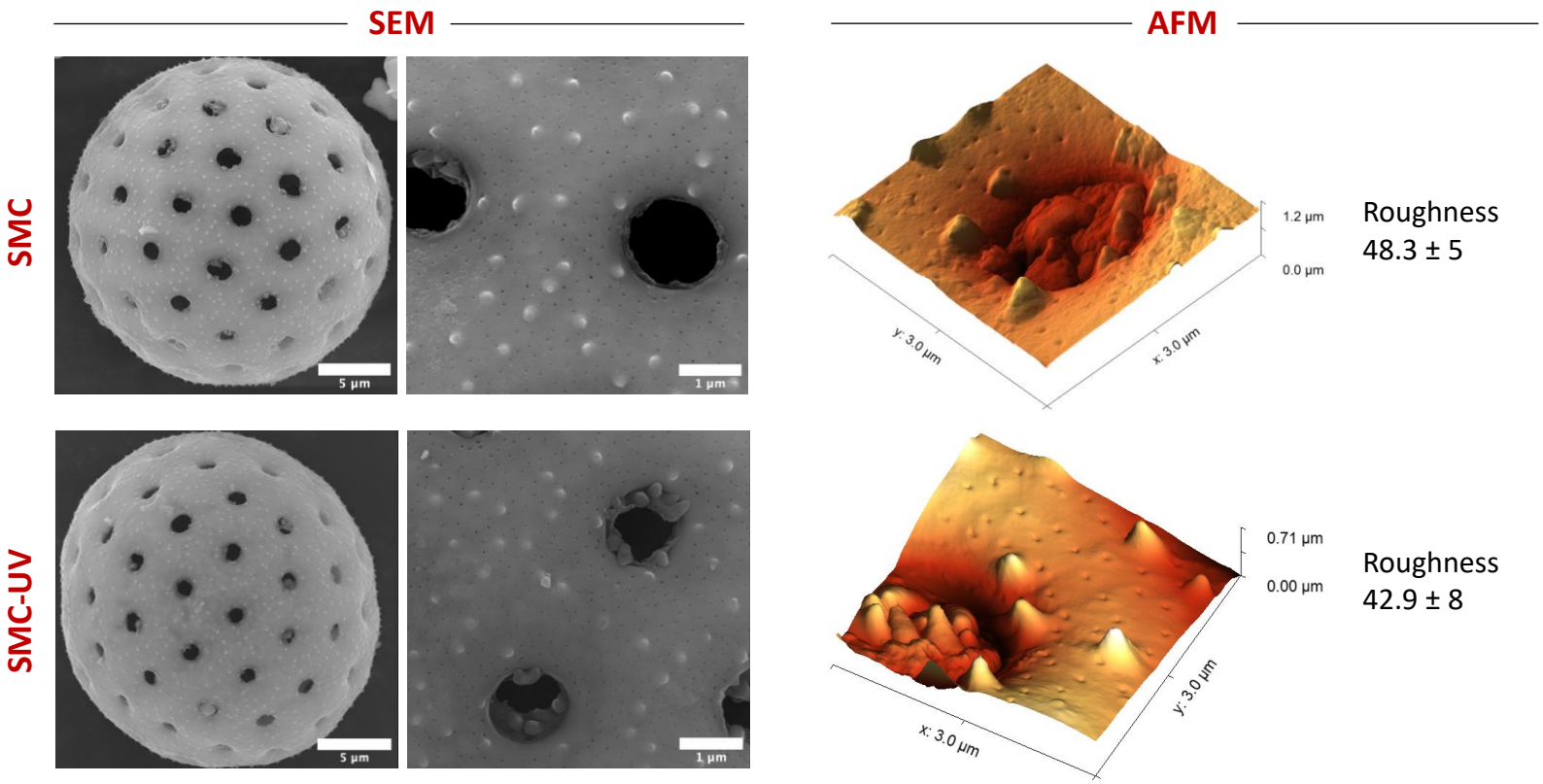
- Water contact angle results show that hydrophobic SMCs are converted to super hydrophilic.



The data are presented as the average of six measurements with standard deviation (n = 6).

Key Findings

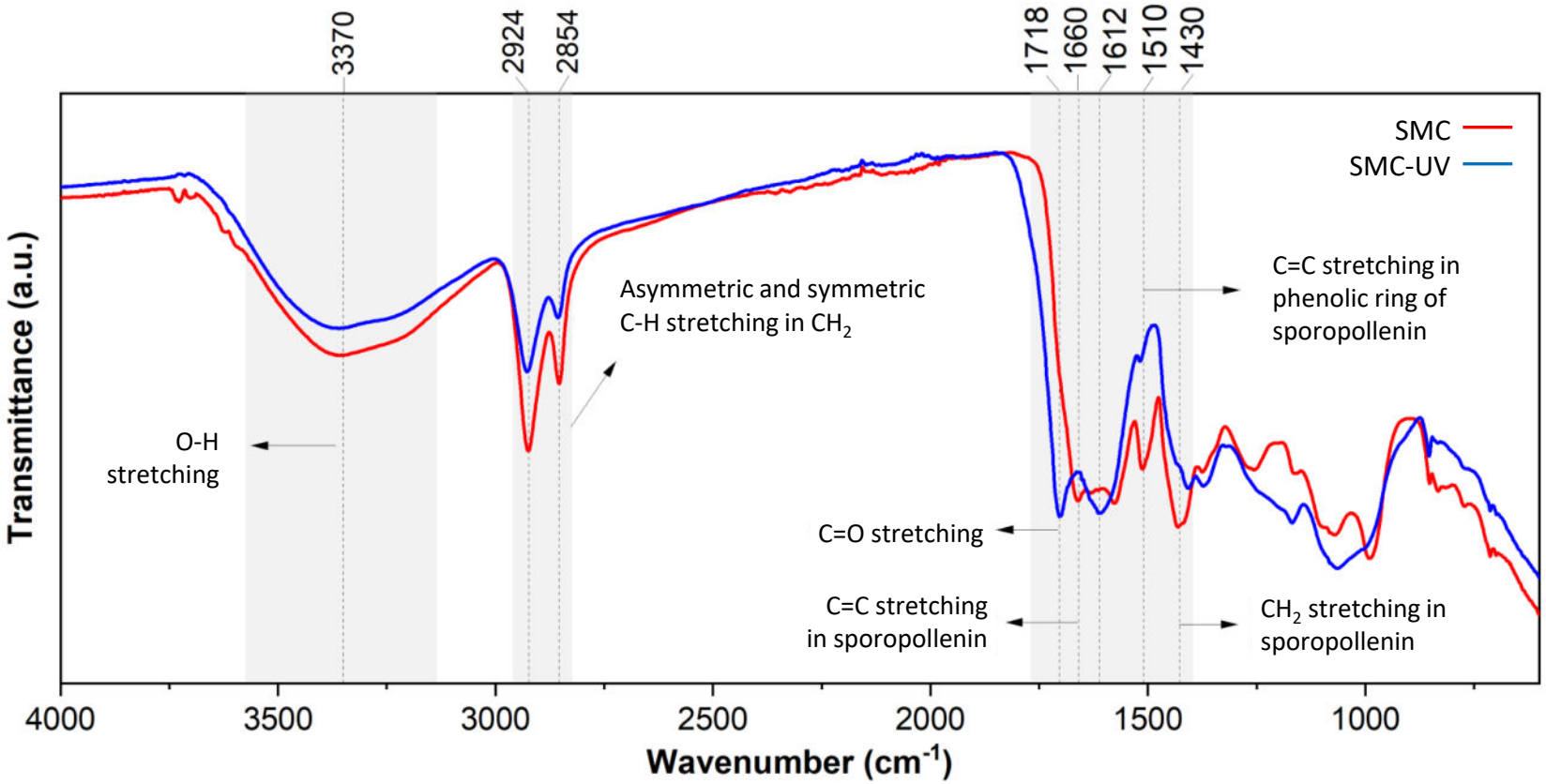
- SEM micrographs and at nanoscale of AFM images showed that UV irradiation did not alter the structural integrity and surface ornamentation of SMCs.



The data are presented as the average of six measurements with standard deviation (n = 6).

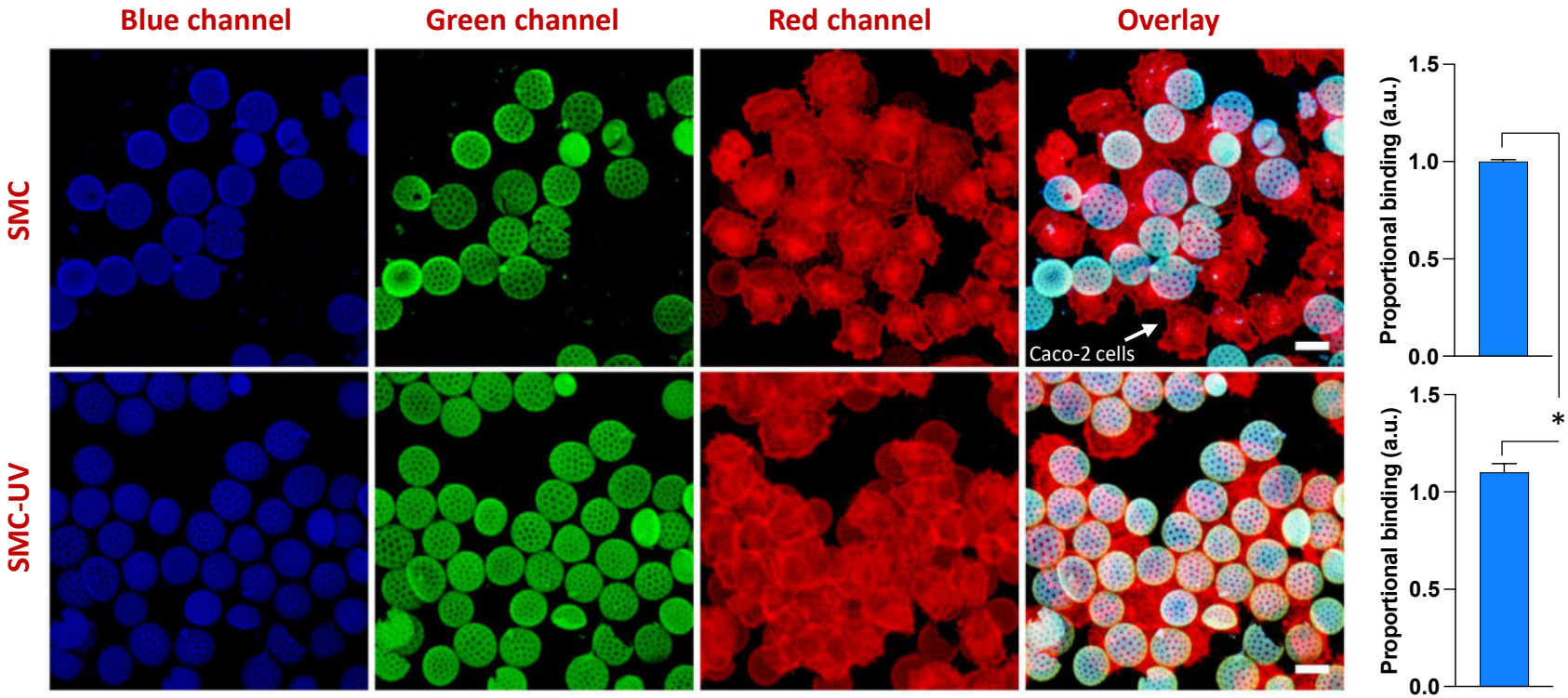
Key Findings

- FTIR spectrum provides some evidence for decreases in C=C binding and concomitant increases in C=O binding.



The data are presented as the average of three measurements with standard deviation (n = 3).

Key Findings

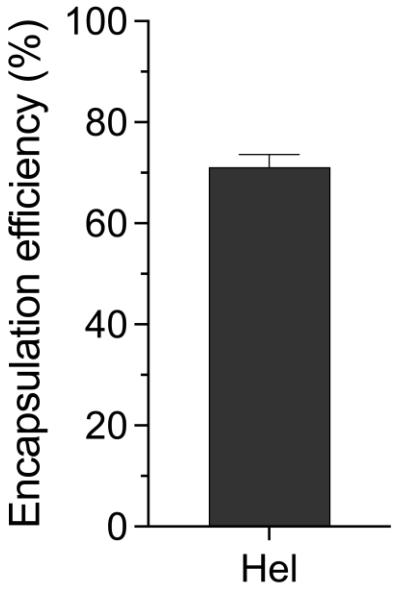


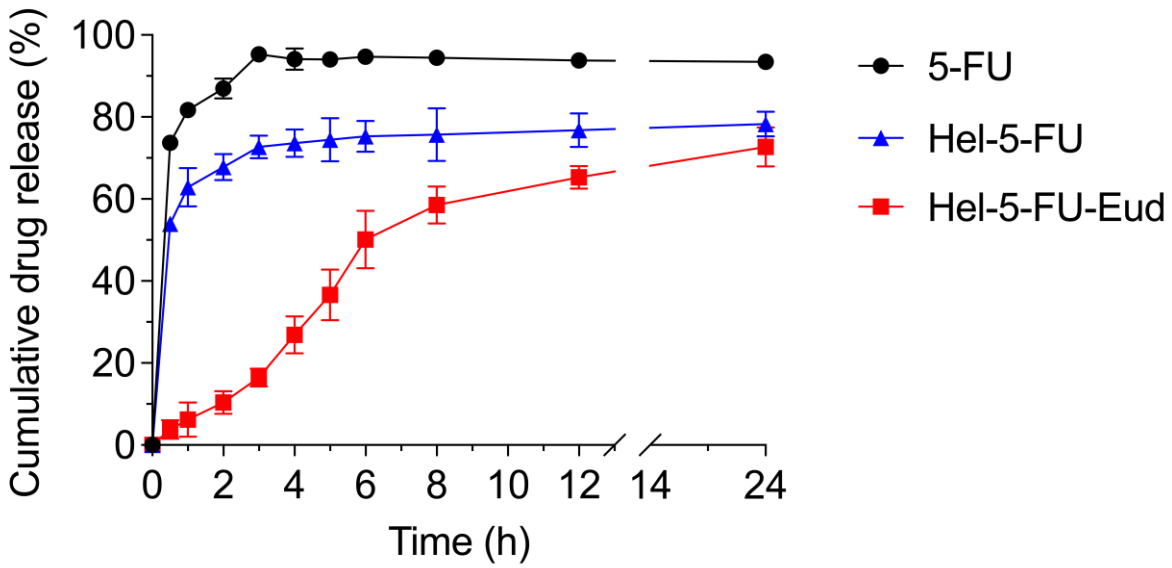
- SMCs and UV-treated ones have no cytotoxicity on the Vero normal cell line.

The data were generated from confocal images (at ×40) taken from 3 different regions of three slides for each sample and presented as the average of measurements with standard deviation (*n* = 9). The scale bar is 20 µm.

Key Findings

- The encapsulation efficiency of Hel-type SMCs reached up to 71%. The release profile of 5-FU-loaded SMCs coated with eudragit showed better performance in the GIT compared to the pure drug and uncoated compartment.

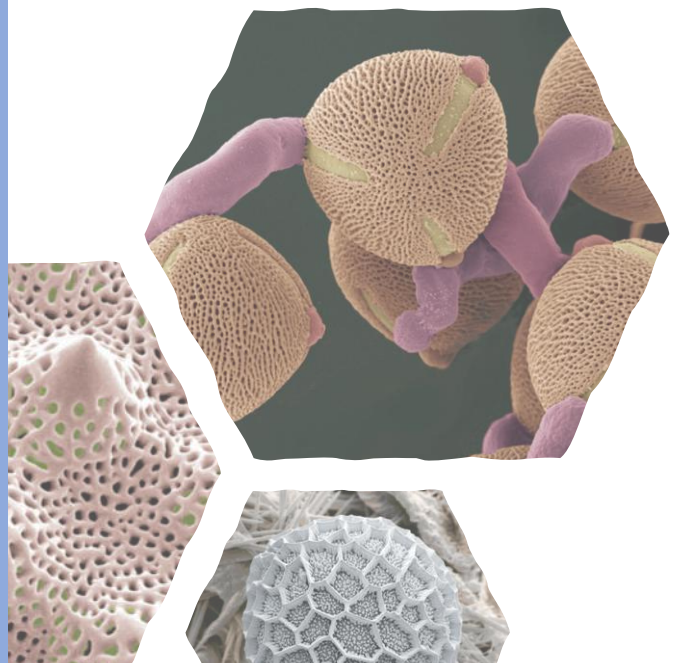




The data are presented as the average of three independent analyses with standard deviation (*n* = 3).

Conclusion remarks

- Pollen grains collected by honeybees can be transformed into stable natural SMCs with diverse morphologies.
- UV treatment makes SMCs hydrophilic, enhancing cell binding without cytotoxicity.
- Bee pollen derived SMCs show strong potential for targeted, sustained oral drug delivery to the intestine and colon.

THANK YOU

FOR YOUR ATTENTION