Microencapsulation of Essential Oils: A Novel Strategy for Eco-Friendly Pest Management

G. Angellotti*, M. Pagliaro and R. Ciriminna

Istituto per lo Studio dei Materiali Nanostrutturati, CNR, Via U. La Malfa, 153, 90146 Palermo (Italy)
*giuseppe.angellotti@cnr.it

The widespread application of synthetic pesticides today poses significant threats to both the environment and human health, challenges that are further intensified by the effects of climate change on agriculture and insect populations. Globally, it is estimated that approximately 3.5 billion kilograms of synthetic pesticides are used annually, contributing to persistent health problems and ecological contamination. As a more sustainable alternative, essential oils (EOs) have gained attention for their potential as biopesticides. Oils extracted from plants such as *Citrus* species, *Origanum vulgare*, and *Rosmarinus officinalis* have demonstrated potent insecticidal, larvicidal, and repellent properties. However, their practical use in agricultural settings is hindered by their high volatility and chemical instability. [1] To overcome these limitations, the sol-gel technique was employed to microencapsulate the active EOs. This process involved creating oil-in-water emulsions stabilized by biocompatible surfactants, which acted as microreactors for the sol-gel hydrolysis and condensation of appropriate silicon alkoxides. The result is the formation of mesoporous silica shells encapsulating the EO droplets. This encapsulation approach significantly improves the stability and shelf life of EOs and facilitates their controlled release. The resulting microcapsules were found to be submicron in size, with high specific surface areas and mesoporous structure. Scanning electron microscopy confirmed their uniform spherical shape and homogeneous size distribution. Quantitative analyses revealed high encapsulation efficiency, highlighting the effectiveness of the sol-gel method for this application. Release studies, also, demonstrated a sustained and controlled release of the EOs over time. Additionally, the pesticidal efficacy of these EO-loaded microcapsules was tested against *Spodoptera littoralis*, a common agricultural pest, with promising results confirming their potential as a biopesticides. [2-3]

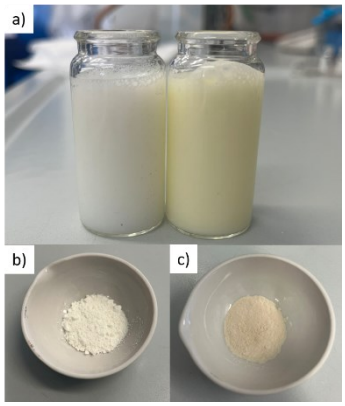

Figure. Microcapsules loaded with essential oils as water dispersion (a) and dried (b,c)

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References

[1] L. Alejandro and E. Guzman. Emulsions containing essential oils, their components or volatile semiochemicals as promising tools for insect pest and pathogen management. Adv. in Colloid and Interface Science, 2020. https://doi.org/10.1016/j.cis.2020.102330

[2] M. Sciortino, A. Scurria, C. Lino, M. Pagliaro, F. D'Agostino, S. Tortorici, M. Ricupero, A. Biondi, L. Zappalà, R. Ciriminna, Silica-Microencapsulated Orange Oil for Sustainable Pest Control. Adv. Sustainable Syst., 2021. https://doi.org/10.1002/adsu.202000280.

[3] Angellotti, G., Riccucci, C., Di Carlo,Pagliaro M., Ciriminna R. Towards sustainable pest management of broad scope: sol-gel microencapsulation of Origanum vulgare essential oil. J Sol-Gel Sci Technol 112, 230–239, 2024. https://doi.org/10.1007/s10971-024-06512-8