

From Field Residue to High-Performance Coatings

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Unlocking the Potential of *Calendula* seed residues

In the transition towards a more circular and bio-based economy, the coatings industry is emerging as a powerful enabler for the valorization of underutilised biomass streams. The transition to sustainable coatings is not only about replacing petrochemical binders, itis equally about rethinking the role of fillers and additives.

Within this context, Sirris is actively contributing through the AddBIO project. This project searches for bio-based additives for high-performance coatings, and more specifically, for sourcing and processing them.

A particularly promising case has recently emerged and is further evaluated in collaboration with ILVO and Praktijkpunt Landbouw. Both organisations are active members in the industrial guidance group of the AddBIO project: the valorisation of residual Calendula seeds after hexane extraction, sourced through the GOGO4IT project

What is often considered waste after extraction may, in fact, represent a high-value functional material. Calendula residues hold untapped potential as bio-based fillers and additives in coatings,

combining performance, sustainability, and circularity. This blog outlines why this material is worth attention, and invites industrial partners to join the journey toward its further development.



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Calendula in Flanders

Calendula officinalis is a new crop for Flanders. Ever since the start of research into Calendula in 2014, Flemish growers have been eager to cultivate it. This group of active and driven growers forms the basis of the technical cultivation knowledge, which is now sufficiently refined to scale up the cultivation.

Until recently, its introduction into the cropping plan was hampered by a lack of sales for the, admittedly promising, raw materials of Calendula cultivation. In 2024, this changed due to a concrete request from a company specialising in sustainable wood coatings. They needed 10 to 100 tonnes of Calendula seed oil annually (source: ILVO).

A new life for *Calendula* seed residues

Calendula officinalis flowers are widely cultivated for its valuable extracts used in cosmetics, pharmaceuticals, and nutraceuticals. At the same time, the Calendula seeds can also be harvested, collected and further processed into valuable components. Hexane extraction primarily removes non-polar compounds such as oils and lipophilic actives, leaving behind a solid fraction that is underexploited (see Figure).

Primary analysis indicated that the extracted residues include high protein and fiber content. It typically retains a lignocellulosic framework (cellulose, hemicellulose, lignin); polar phytochemicals that are not hexane-soluble; natural pigments such as carotenoids; a porous, lightweight structure; reactive surface hydroxyl groups. Calendula seed residues are currently already used as soil fertiliser, or co-feedstock in biorefinery. The above characteristics make them potentially attractive as a functional filler in biocomposites, coatings, pigments or **biochar** source.



Figure: microscopic observation of fibrous seed residues from Calendula officinalis after hexane extraction, available as biomass for functional coating applications (© Sirris).

What makes calendula residues a functional additive for the coatings industry?

The coatings industry is continuously searching for sustainable alternatives to mineral fillers (e.g. CaCO?, talc), additives that offer multifunctionality, materials that contribute to CO? reduction and circularity targets, and aid at differentiation through bio-based content. Calendula seed residues align strongly with these needs. Unlike many agricultural by-products, they offer a fine structure and intrinsic chemical functionality. They thus offer pathways to serve both in drop-in applications and higher-value engineered solutions.

The most immediate and scalable application to be prospected is to use it as a **functional filler**. After drying and milling, Calendula seed residues can be incorporated into coatings to provide **rheology control** (through particle-particle interactions), **matting effects** (due to surface roughness and light scattering), **weight reduction** (lower density compared to mineral fillers), or **crack resistance** (improved stress distribution).

In this role, Calendula seed residues can **partially replace conventional fillers**, contributing to both sustainability and performance. This is particularly relevant for: waterborne acrylic coatings, alkyd systems, or epoxy coatings. In particular, the high protein content may help enhance chemical crosslinking of the coating with improvement in longevity and mechanical resistance. The key in future development lies in optimising particle size distribution, dispersion quality, and moisture control to optimise coating formulation with maximised contact of bio-based additives.

One of the most exciting aspects of Calendula seed residues is their **chemical tunability**. Thanks to the presence of hydroxyl groups and reactive surfaces, they can be modified through silanisation (improved compatibility with polymer matrices), fatty acid treatment (enhanced hydrophobicity), and esterification or grafting (reactive integration into binders). This allows the transformation of a simple filler into a functional additive with tailored interfacial properties. The possible benefits may lead to improved dispersion stability, enhanced mechanical performance, reduced viscosity penalties, and better water resistance. For the coatings industry, this represents a shift from filler substitution to performance-driven formulation design.

Aiming at higher performance of bio-based coatings

For high-performance applications, Calendula seed residues can be converted into biochar via pyrolysis. This produces a carbon-rich material with increased hydrophobicity, potential electrical conductivity, and enhanced UV stability. Such materials can be used in antistatic coatings, corrosion protection systems, or specialty industrial coatings. While this route requires additional processing, it may unlock high-value niche applications.

In parallel, Calendula flower residues are already available on a more common base and may serve as vibrant color pigments. Even after solvent extraction, residual coloration and UV-active compounds can be produced. Potential applications include soft tinting in decorative coatings, natural aesthetic finishes, and supplementary UV protection.

Looking for partners to explore and collaborate

To unlock the full potential of Calendula seed residues, a structured development approach is essential. Calendula residues represent an easily accessible source with high innovation potential:

- Available as a side stream in the testing phase
- Requires relatively simple processing for initial applications
- Offers multiple functionality pathways
- Strong alignment with regulatory and market trends

By engaging now, partners can:

- Shape the value proposition early on
- Develop application-specific solutions
- Gain a competitive advantage in sustainable coatings

The valorisation of Calendula seed residues is not just a technical opportunity, it is a collaborative innovation challenge. Sirris and ILVO are actively seeking industrial partners to explore and co-develop this promising material in Flanders as a high-value product. We are particularly interested in collaborations with coating manufacturers wanting to integrate bio-based fillers, looking to differentiate with circular materials, or exploring low-carbon formulations. Moreover, we want to collaborate with raw material suppliers open to developing and scaling modified bio-fillers, or looking to expand their sustainable portfolio.

Are you interested in exploring the use of Calendula-based fillers or co-developing new coating concepts?

You can request a sample of the marigold seed residues by contacting Sirris or ILVO. The seed oil itself is also available for further testing.

We invite you to join us in transforming agricultural residues into high-value materials. Together, we can develop coatings that are both high-performing and truly circular.

Contact our expert Contact ILVO

Want to learn more about the AddBIO project?

Discover how the AddBIO project is advancing the development, sourcing, and processing of bio-based additives for high-performance coatings.

Learn more about AddBIO

Partners

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