

Eggshell-derived CaCO_3 as a Renewable Extender in Marine Protective Paint

INDONESIA

Key Concepts- Renewable feedstock; circular economy; eggshell-derived CaCO_3 ; marine protective paint

Central Problem

In marine coatings, calcium carbonate (CaCO_3), typically derived from limestone, is one of the most commonly used extenders due to its widespread availability, low cost, and chemical inertness. Conventional CaCO_3 extenders are sourced through limestone quarrying. These activities are associated with environmental impacts such as land degradation, habitat destruction, dust and noise emissions, and increased CO_2 emissions from machinery and material transport.

Potential Solution

Sigma Utama, a paint manufacturer, synthesizes calcium carbonate from eggshells using a wet precipitation method to produce precipitated calcium carbonate (PCC) with optimal characteristics.

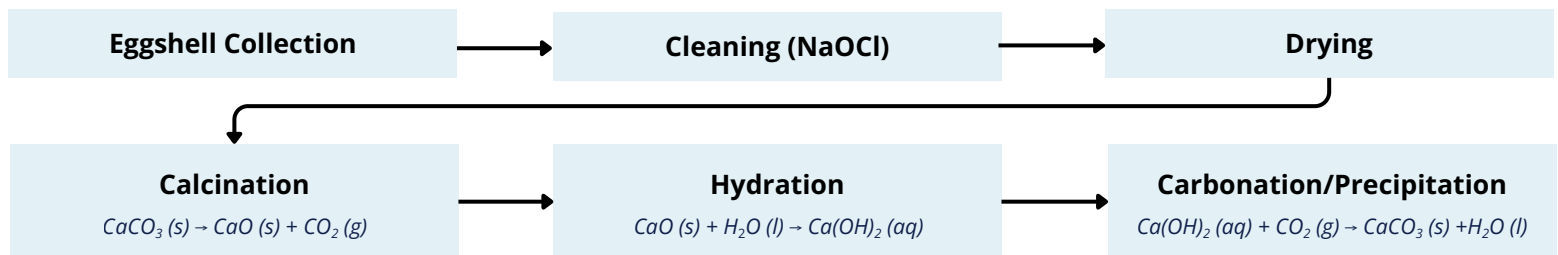


Fig 1. Process flow for the synthesis of calcium carbonate (CaCO_3) from eggshells

The CaCO_3 is filtered, purified, and dried to produce a ready-to-use paint extender. The resulting CaCO_3 is integrated into base white paint formulations as a sustainable extender, without altering standard resin and pigment systems.

Performance

- 1 Superior Coverage & Efficiency**
Eggshell-based paint achieved higher opacity (93.42%) than the standard (88.3%), providing better coverage and reducing coating layers, material use, and costs.
- 2 Excellent Application Performance**
Both formulations showed smooth application, uniform finish, and no defects, while maintaining ease of use and workability.
- 3 Sustainable High-Performance Alternative**
Eggshell-derived CaCO_3 is a viable eco-friendly substitute with potentially enhanced performance.



Fig 2. Visual appearance of paint formulated with eggshell-derived CaCO_3 as extenders (Sample).



Impact Assessment Analysis

Table 1. Comparative assessment of eggshell-derived CaCO₃ vs conventional limestone-based

Aspects	Eggshell-derived CaCO ₃	Conventional Limestone-based CaCO ₃
Raw Material	Eggshell (waste-derived)	Limestone (non-renewable mineral resources)
Extraction Process	<ul style="list-style-type: none"> Eggshell waste collection Cleaning (NaOCl treatment) Drying 	<ul style="list-style-type: none"> Quarry mining Crushing and mineral processing
Performance	Higher opacity (93.4%), improved coverage	Lower opacity (88.3%)
Environmental Impact	Lower environmental impact, with minor trade-offs in toxicity-related categories due to NaOCl use and energy consumption.	High environmental burden, particularly in global warming, resource depletion, and air pollution.

Life Cycle Assessment (LCA)

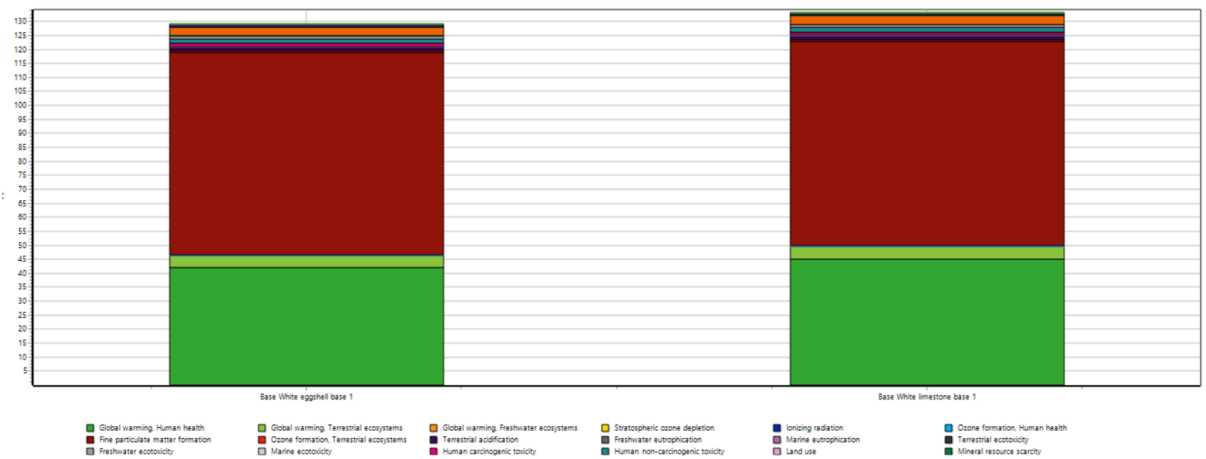


Fig 3. Comparative LCA results for eggshell-derived and limestone-based CaCO₃

Lesson Learned/Key Takeaways

1 Process optimization in eggshell-derived CaCO₃ production

While eggshell-derived CaCO₃ shows clear environmental advantages, further optimization of processing steps, particularly chemical use (e.g., NaOCl) and energy consumption, is needed to minimize remaining impacts.

2 Minor contribution of extender to overall environmental impact

In base white paint formulations, the extender has a limited environmental influence, as it constitutes only ~8% of the total formulation. Hence, the magnitude of change is moderate rather than dominant.



Market Relevance

Calcium carbonate (CaCO_3) is a critical material in the coatings industry and is used at large scale across multiple sectors. While both limestone and eggshells consist of $\sim 95\%$ CaCO_3 , their sourcing pathways differ significantly. Limestone requires extraction, whereas eggshells are generated as waste. Eggshell waste is recognized as a significant environmental issue in the food industry, with improper disposal leading to health risks and environmental contamination.

