

# CARBON-FIXING CEMENT

2023-LADI-69960

## PROBLEM

The synthesis of oxalic acid from existing carbon dioxide has traditionally been impeded by high energy costs and severe pollution.

## SOLUTION

Researchers at Purdue University have developed an acid-base cement formulation that has a carbon-negative impact, removing more carbon from the atmosphere than what's emitted during manufacturing and transport. This method converts lignocellulosic materials to fermentable sugars, increasing the strength of the cement and affects hydration. This technique also prevents corrosion in the long-term, providing a viable eco-friendly alternative to current systems.

## VALIDATION

The researchers have successfully produced oxalic acid from corn stover.

## ADVANTAGES

- 10 times reduction in shrinkage
- Highly tailorable strength
- Protection from corrosion
- Calcination-free

## APPLICATIONS

- Construction

## INTELLECTUAL PROPERTY STATUS

**Application Date:** July 24, 2023 | **Type:** Provisional Patent | **Country of Filing:** United States

**Application Date:** July 23, 2024 | **Type:** PCT-Gov. Funding | **Country of Filing:** United States

**Application Date:** January 23, 2026 | **Type:** NATL-Patent | **Country of Filing:** United States

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# PLANT-DERIVED ADDITIVES TO IMPROVE THE SUSTAINABILITY AND PERFORMANCE OF CEMENT

2023-YOUN-70131

## PROBLEM

Traditional engineering practices are often unsustainable and industry is looking more and more towards materials with a minimal carbon footprint. The Purdue innovations offers a naturally sourced solution to make cement more eco-friendly and reduces the volume and demand of raw materials.

## SOLUTION

Researchers have developed a chemically modified (CM) version of the renewable and abundant nanocellulose by altering the material to improve its ability to increase the strength and resilience of cement. This technology offers increased strength and resiliency in the construction of roads, bridges, and buildings. It also supports the widespread effort to divert from traditional, unsustainable engineering practices and instead opt for materials with a minimal carbon footprint.

## VALIDATION

Mechanical tests showed an increased flexural strength of approximately 30% with 0.2% volume of cellulose nanocrystals integrated into the cement. This result is hypothesized to be from an increase of degree of hydration (DOH) in the cement paste when cellulose nanocrystals were used, which was validated through isothermal calorimetry (IC) and thermogravimetric analysis (TGA).

## ADVANTAGES

- Increased strength and resiliency of materials
- Improved mechanical performance
- Reduces carbon footprint of cement

## APPLICATIONS

- Infrastructure
- Manufacturing
- Construction

## INTELLECTUAL PROPERTY STATUS

**Application Date:** February 15, 2024 | **Type:** Utility-Gov. Funding | **Country of Filing:** United States

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# NOVEL POLYMER-SILICATE ADMIXTURE FOR STRONGER AND LONGER-LASTING CEMENT

2024-ERK-70594

## PROBLEM

Silica additives (silica fume, nanosilica) and calcium-silicate-hydrates (C-S-H) seeding agents are widely popular in the cement industry to help create high-strength 'glue' within cement that binds together concrete aggregates. However, the silica-based particles can produce significant inhalation hazards when incorporated into cement.

## SOLUTION

Researchers have developed a multifunctional powdered polymer-silicate admixture that produces stronger and longer-lasting cement. This technology helps concrete contractors create concrete with greater strength and service life by reducing concrete compaction and shrinkage during placement while encouraging and controlling the growth of strengthening phases (C-S-H seeding).

## VALIDATION

A rheological analysis and swelling measurements were conducted to provide evidence for the successful incorporation of pH responsive organic silicate groups within the admixture particle. Rheometry data showed a greater storage modulus than loss modulus, indicating the transition from a liquid solution to a solid gel-like material with the addition of silicate groups that function as crosslinks with the polymer particle. Swelling data showed that absorption capacity was reduced for admixture particles that contained greater amounts of the organic silicate groups.

## ADVANTAGES

- Combined properties of seeding, air entraining, and internal curing
- Enhanced safety profile
- Produces high-strength and longer lasting cement, helping to reduce carbon emissions

## APPLICATIONS

- Concrete admixture manufacturing
- Concrete production
- Concrete additive manufacturing (concrete 3D printing)

## INTELLECTUAL PROPERTY STATUS

**Application Date:** February 21, 2025 | **Type:** Utility Patent | **Country of Filing:** United States

**Application Date:** February 5, 2019 | **Type:** Provisional-Patent | **Country of Filing:** United States

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# MIMICKING OYSTER REEFS TO GENERATE CEMENTS WITH ENHANCED PERFORMANCE

2026-WILK-71316

## PROBLEM

Traditional Portland cement is energy-intensive to produce and weak in tension, while conventional PMCs often compromise compressive strength.

## SOLUTION

Researchers at Purdue University have developed a new class of biomimetic polymer-modified cements (PMCs) inspired by the unique adhesive used by oysters to construct reef structures. The material surpasses commercial masonry sealant benchmarks and, when added to a commercial mortar mix, substantially increases both adhesion and compressive strength.

## VALIDATION

The methacrylate polymers performed well when phosphates were added, with p(MePhos-MeAc-MeNaAc) having the highest adhesion of  $5 \text{ } \hat{\text{A}} \pm 2 \text{ MPa}$  (or  $4.6 \text{ } \hat{\text{A}} \pm 1.7 \text{ MPa}$ ). Elmer's Glue-All achieved a bonding of  $1.1 \text{ } \hat{\text{A}} \pm 0.3 \text{ MPa}$ , and Loctite Super Glue was  $4.9 \text{ } \hat{\text{A}} \pm 0.5 \text{ MPa}$  for these conditions. These results show that the phosphate-functionalized, sodium-containing methacrylate polymer p(MePhos-MeAc-MeNaAc) had nearly similar strength to the commercial counterparts.

## ADVANTAGES

- Enhanced performance in adhesion and compressive strength
- Sustainable approach

## APPLICATIONS

- High-performance mortars and concrete
- Specialty adhesives and sealants
- Sustainable building materials

## INTELLECTUAL PROPERTY STATUS

**Application Date:** August 22, 2025 | **Type:** Utility-Gov. Funding | **Country of Filing:** United States

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