



## HIGH RENEWABLE CONTENT EPOXY RESINS FOR A GREENER FUTURE

**High performance SPERLU™ epoxy resins contain up to 80% bio-based content.**

Epoxy resin is a critical component of an increasing number of high-performance composites, coatings and structural materials used in many industries. Yet despite the growing popularity of epoxy resins, traditional epoxy resins are made from petroleum and are not sustainable. One emerging technology that overcomes these issues is SPERLU™ renewable epoxy resins. Spero Renewables, LLC, a clean technology development company based in Santa Barbara, CA has developed the SPERLU™ process to produce 100% bio-based epoxy prepolymers from lignin.

Lignin is an abundant and low-cost byproduct of papermaking processes, and the sole large-volume sustainable aromatic feedstock. The aromatic structure of lignin provides the SPERLU™ products with thermal and mechanical performance rivaling petroleum-based alternatives.

In previous efforts to create materials from lignin, the brittle nature, low solubility, high viscosity and incompatibility of unmodified lignin with other polymeric networks have greatly restricted lignin's application in high performance materials.

The SPERLU™ technology overcomes these challenges and delivers high solubility, reactivity, and compatible epoxy prepolymers that allow for tunable strength and record-breaking high renewable content in epoxy resins. The ability to achieve up to 80 wt.% renewable content in SPERLU™ epoxy resin (epoxy pre-polymer + hardener) using SPERLU™ epoxy prepolymers is attributed to their aromatic structure and multiple epoxy functions, which provide resins with high strength and stiffness.

By comparison, other renewable sources like epoxidized soybean oil or epoxidized cashew nut shell liquid are generally non-aromatic and flexible. The low strength of these competing epoxy prepolymers restricts the total renewable content possible in epoxy resins to about 20 wt.%.



**HIGH RENEWABLE CONTENT**

Up to 80% of resin mass comes from nature



**HIGH AND TUNABLE PERFORMANCE**

Tunable  $T_g$  to up to 160°C and high strength



**ABUNDANT & NON-COMPETE WITH FOOD**

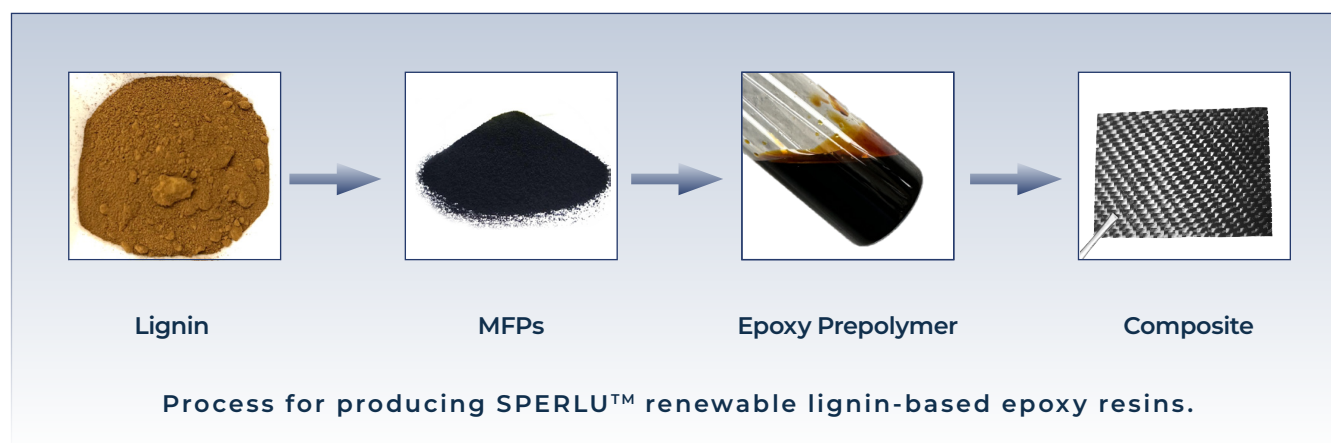
Lignin is a byproduct of pulping and produced >100 million tons/year



**UPCYCLING AND INCREASED VALUE**

Instead of burning, upcycle lignin waste to resin

**Advantages of SPERLU™ renewable epoxy resins**

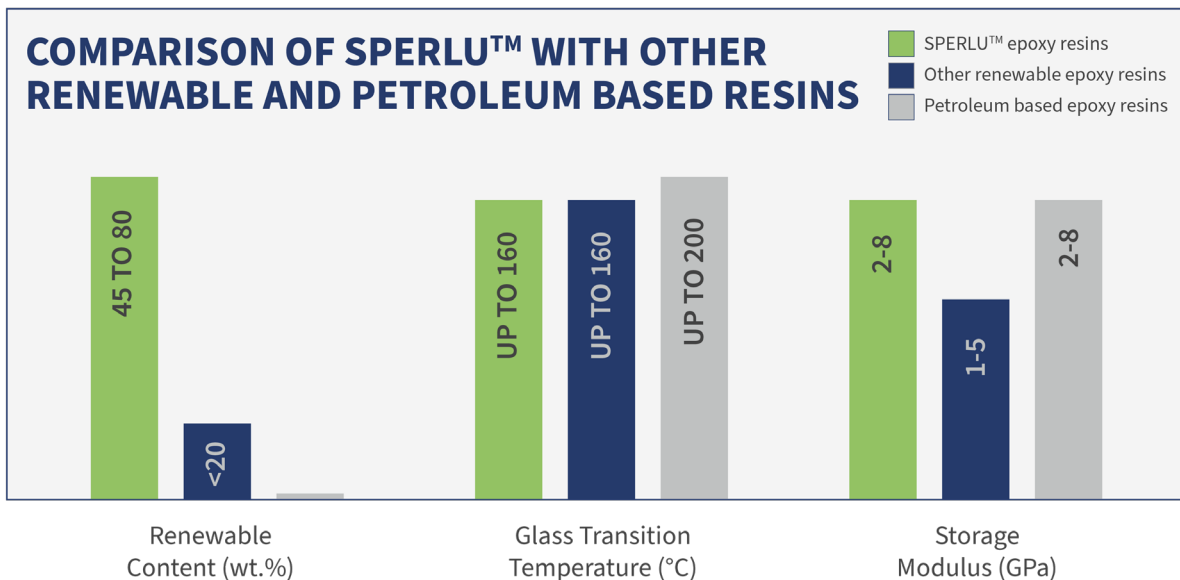


SPERLU™ utilizes a novel catalytic lignin depolymerization process to produce multifunctional phenols (MFPs) with a controlled narrow molecular weight distribution. Spero uses an abundant and commercially available technical lignin feedstock for the SPERLU™ process. While the molecular weight of the lignin feedstock ranges from 10,000 to 50,000 Daltons (Da), the Spero Renewables' MFPs have molecular weight around 300 Da. Since the molecular weight is significantly reduced, solubility and reactivity of MFPs are highly improved.



This allows MFPs to directly react with epichlorohydrin in the same style as the glycidylation of bisphenol A. Unlike bisphenol A that is made from the coupling of phenol, or other renewable phenol monomers that need to be modified into multifunctional dimers and/or oligomers, SPERLU™ MFPs are multifunctional by nature and no coupling modification is needed.

*One application of SPERLU™ renewable high performance resin is sporting goods like surfboards.*



SPERLU™ epoxy prepolymers have favorable viscosities, comparable to leading epoxy prepolymers, and can be cured with traditional hardeners to achieve epoxy resins with renewable content up to 80 wt%. This is much higher than any leading competitors whose renewable content is advertised to be ca. 20%. SPERLU™ epoxy prepolymers also have outstanding miscibility with bisphenol A diglycidyl ether (DGEBA), allowing formulators to easily tune renewable content and mechanical properties. By mixing SPERLU™ epoxy with bisphenol A diglycidyl ether, renewable content of 45-80 wt%, glass transition temperature ( $T_g$ ) range of 65-160°C and storage modulus of > 2000 MPa can be achieved. The wide range of  $T_g$  and high strength make SPERLU™ epoxy resins suitable for a wide range of applications including automotive, wind turbines, sporting goods and fiber reinforced composites.

SPERLU™ epoxy resin offers many compelling advantages in terms of unbeatable high renewable content, replacement of petroleum-based bisphenol A, and low viscosity and high uniformity for resin and composite applications. This promising work allows for high-performance resins to be made with the highest bio-based content commercially available, and is sourced from sustainable and widely available lignin.

Spero Renewables, LLC is seeking commercialization partners and customers as this exciting SPERLU™ technology is commercialized. SPERLU™ epoxy resin samples are available for formulators seeking a direct bio-based replacement for DGEBA.

**To learn more visit**

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