

## VANISPERSE LI ADDITION: POWDER VERSUS LIQUID

### Technical Questions

Can Vanisperse LI be added as a powder or liquid form? Can Vanisperse LI be combined with a binder solution before addition to the active material?

### Application & Background

Electrode production accounts for nearly 40% of total lithium-ion battery manufacturing costs – with the most common challenges arising during mixing, coating, and drying. Vanisperse LI simplifies these steps by improving material behavior and enhancing electrode properties. Challenges with the implementation of new materials and the scale-up of optimized slurries are reduced when additives have several different means of preparation.

### Case Study & Technical Explanation

Vanisperse LI was added to aqueous graphite slurries replacing 50% of the binder as a powder, as a pre-dissolved solution, and as a pre-dissolved solution in combination with carboxymethyl cellulose (CMC). The viscosity curves in Figure 1 illustrate both the reduction in viscosity that is achieved with the addition of Vanisperse LI and the identical viscosity decrease regardless of if Vanisperse LI was added as a powder or liquid form.

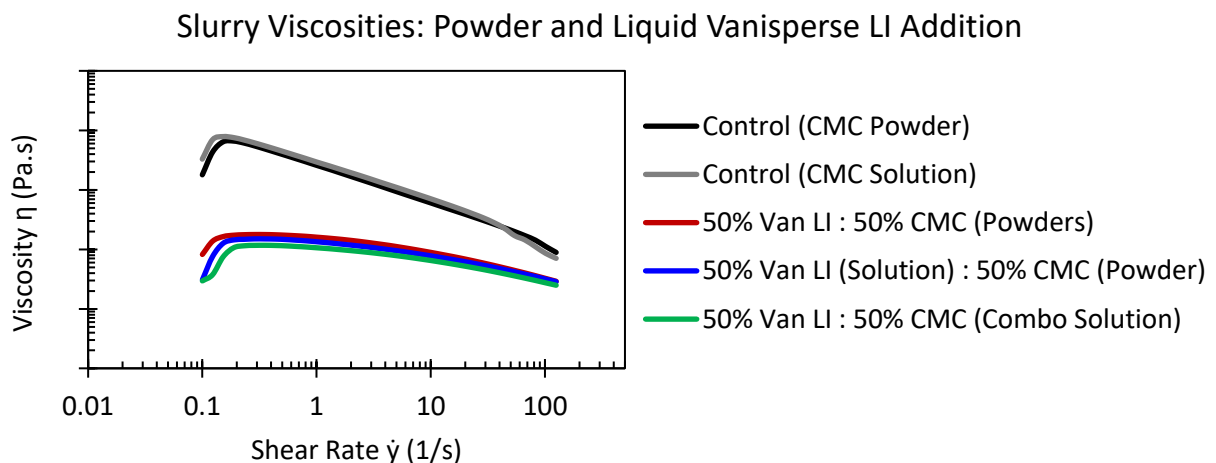


Figure 1. Viscosity curves of aqueous graphite anode slurries showcasing the identical viscosity reduction achieved regardless of if Vanisperse LI is added as a powder, solution, or as a combination solution with pre-dissolved CMC.

## Practical Recommendations & Limitations

Due to the large variation in materials and formulation ratios, a small dosage study is recommended to optimize slurry solution and cast electrode properties. Large substitutions of CMC with Vanisperse LI in formulas with small amounts of CMC ( $\leq 1$  wt%) may result in material settling. Details of the slurry formulation and mixing method used in this case study can be found in the *Experimental Procedure* section.

## Conclusions

Vanisperse LI is a bio-based additive designed to increase the performance of aqueous-based electrodes, decrease electrode production costs, and reduce scrap during manufacturing. This product can be introduced to a formulation either as an additive or as a substitute for CMC depending on the system challenges. Vanisperse LI can be added to slurry formulations as either a powder or liquid form, and can also be pre-dissolved in CMC solutions for easier addition. By improving dispersion and viscosity, Vanisperse LI improves electrode coating uniformity, increases slurry solids, reduces manufacturing costs and scrap rate while simultaneously improving battery performance.

## Experimental Procedure

Electrode slurries were prepared at a  $\sim 50$  g scale using a Eirich EL-1 Nano mixer and “Pin” rotor head. The mixing method for preparing slurries can be found in Scheme 1 and the materials used can be found in Table 1. Slurry solids measured to be  $\sim 53\%$  with a moisture balance.

*Scheme 1. Borregaard’s method for preparing aqueous-based graphite slurries with an Eirich mixer. Note: CMC and Vanisperse LI solutions were added after dry mixing to achieve kneading.*

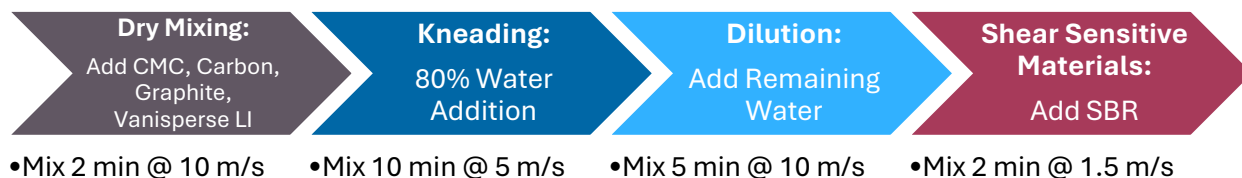


Table 1. List of materials in Borregaard's electrode slurry preparation.

<b>Chemical</b>	<b>Description</b>	<b>Composition</b>
<b>Graphite</b>	High Energy Density graphite from <i>MSE</i>	92%
<b>Carbon</b>	Super P C45 carbon black	3%
<b>CMC</b>	CMC (700 kDa) Battery Grade from <i>MSE</i>	3%
<b>SBR</b>	Li battery grade SBR from <i>MSE</i> ; 50% solution	2%
<b>Vanisperse LI</b>	Bio-based lignosulfonate	0 – 3%