VANISPERSE LI

The new organic additive for lithium-ion batteries

VANISPERSE® LI

Borregaard's bio-based battery additives are designed for use in water-based slurries for the dispersion of organic and inorganic active materials. Sourced from sustainably managed forests, our products are non-toxic, environmentally friendly, and highly effective. Vanisperse LI provides a uniquely climate-friendly alternative and a lower carbon footprint than fossil-based additives.

Efficient dispersion of carbons is critical for achieving desired electrode homogeneity and obtaining optimal Li-ion battery performance. When Vanisperse LI is used to partially displace carboxymethyl cellulose (CMC) in aqueous anodic slurries, the viscosity is diminished. Battery performance is improved while less water is needed during slurry preparation and less energy is required for electrode drying. The end result is a better performing, less expensive Li-ion battery with a smaller carbon footprint.

Vanisperse LI can be used as an effective dispersant for a wide range of carbon materials in Li-ion battery electrodes, including conductive carbons. It is a modified lignin biopolymer derived from Norway spruce that adsorbs onto the carbon material and imparts steric and electrostatic stabilisation. It thereby functions as a rheology modifier and dispersion stabiliser, achieving improved fluidity for systems containing high concentrations of dispersed materials. Figure 1 clearly illustrates the Vanisperse LI difference in achieving a suitable aqueous dispersion of Super P C45 conductive carbon. Displayed on the left is Super P C45 in water alone. Large aggregates are clearly visible and will manifest in a poor performing electrode with large inhomogenities.

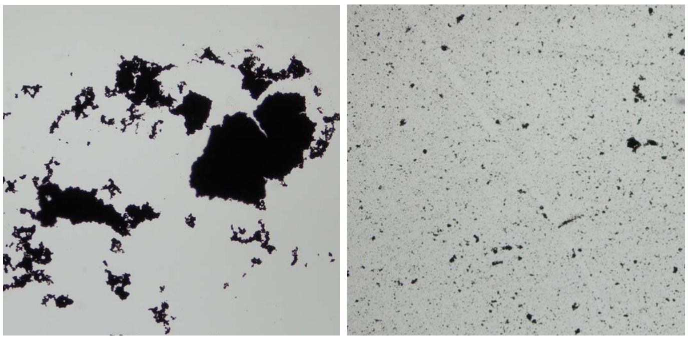

Figure 1: The effect of Vansiperse LI on the dispersion of Super P C45 in water.

On the right, a modest dose of only 1 wt% Vanisperse LI affords well-dispersed carbon particles.

Corresponding results were also observed when Super P C45 carbon slurries were cast on a Hegman gauge, as in Figure 2. While large agglomerates are clearly visible when Vanisperse LI is omitted, addition of 1 wt% Vanisperse LI yields a highly dispersed system.

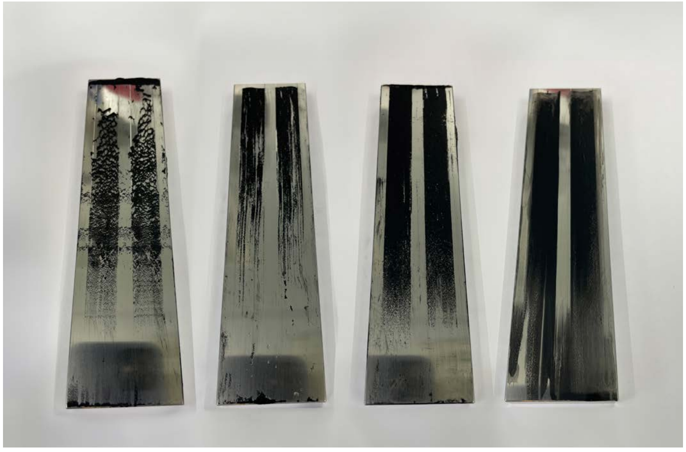

Figure 2: Hegman gauge demonstration of Super P C45 carbon dispersed with 0 wt% (left), 0.1 wt%, 1 wt%, and 5 wt% (right) Vanisperse LI at 5% solids in water.

Slurry viscosity correlates with qualitative observations obtained by microscopy or Hegman gauge. As observed in Figure 3, a viscosity minimum is obtained with a 1wt% Vanisperse LI dosage, with subsequent viscosity build upon addition of more Vanisperse LI. Analogous trends can be observed with other carbons spanning a wide range of surface areas.

CARBON	SURFACE AREA
KS-6 (Graphite)	26 m²/g
Timcal Super C45	45 m²/g
Timcal Super C65	62 m²/g
Ketjen Black EC300J	360 m²/g
Ketjen Black EC600JD	1270 m²/g

Table 1: Surface areas of select conductive carbons of relevance to Li-ion battery production.

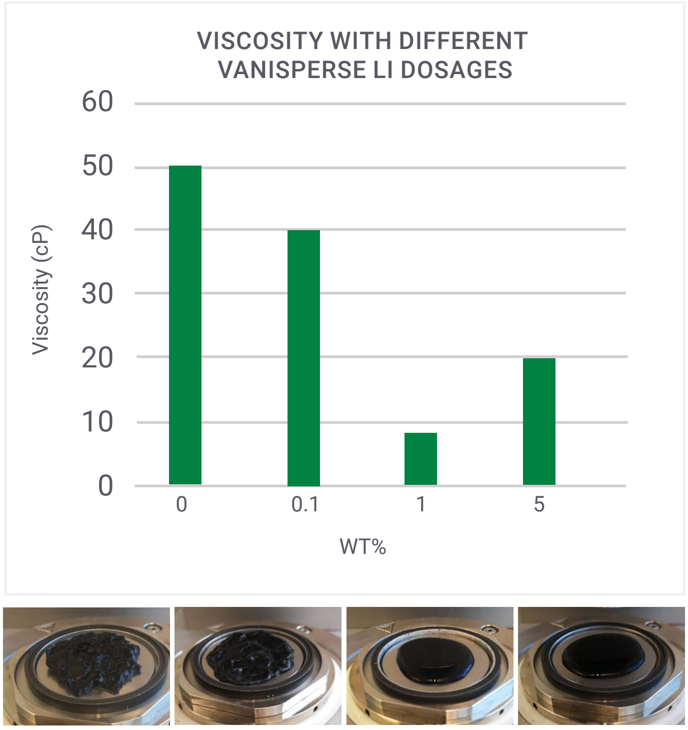

Figure 3: Viscosity of aqueous slurry of 5% Super P C45 conductive carbon with different doses of Vanisperse LI. Viscosity values were used at a sheer rate of 1s⁻¹, with comparable ratios obtained at all rates from 0.1-10k. Images of slurres with 0-5 wt% Vanisperse LI (bottom).

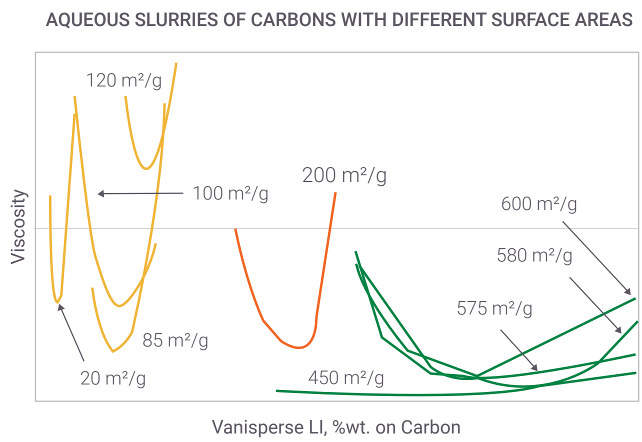

Figure 4: Effect of Vanisperse LI dosage on aqueous slurries of conductive carbons with different surface areas.

Figure 4 shows the effect of Vanisperse LI on aqueous slurry viscosity for a wide range of conductive carbons with varying surface areas. While a viscosity minimum can always be achieved with the addition of Vanisperse LI, adding more is not always better. As a matter of practice, at least three different doses should be evaluated to assess the response of the viscosity to further dosage, taking note that carbons with smaller surface areas have narrower minima and will require care in rheological optimisation. A good starting point for finding the minimum rheology is to use 1 mg Vanisperse LI for every square meter of carbon surface area, as displayed in Table 2. It is important to understand this is only an estimate and will require optimisation, as is seen for Super P C45 where the viscosity minimum is 1% (0.2 mg/m²), and not 5% (1.1 mg/m²).

Surface Area	Max Loading	Van. LI Req (wt%)	Wt of Van LI per g	mg Van LI/m² Carbon
20	50	2	0.02	1.0
85	40	9	0.09	1.1
100	40	10	0.1	1.0
200	27	28	0.28	1.4
450	21	40	0.4	0.89
575	22	50	0.5	0.87
600	24	48	0.48	0.80

Table 2: Vanisperse LI loading as a function of carbon surface area.

Dispersion stability also is an important consideration for industrial electrode preparation, and while small particle size is a component of achieving a stable solution per Stoke's Law, it is not a guarantee. Figure 5 displays stability data quantified with a Turbiscan. In these measurements, the particle distribution throughout a sample volume is measured over time. On a scale from 0 to 3, TSI values denote the extent to which particles have sedimented, with the slope of the plot representative of the sedimentation kinetics. For Super P C45 carbon in water, rapid sedimentation is observed within the first minute of measuring. In contrast, addition of as little as 0.1 wt% Vanisperse LI delays sedimentation, while a 1 wt% or greater dose achieves a stable solution.

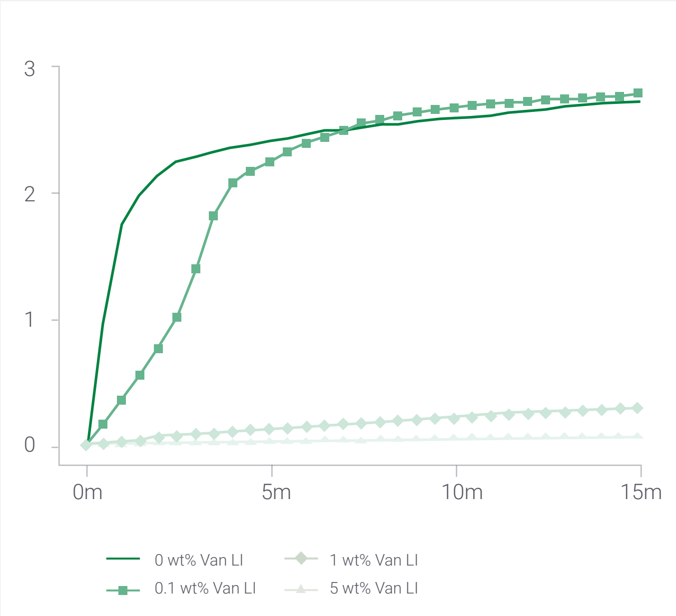

Figure 5: Stability of Super P C45 in water with different doses of Vanisperse LI. TSI values quantify the amount of particle settling as a function of time. Low values are indicative of highly stable solutions and are measured on a scale from 0 to 3.

When Vanisperse LI is used, carbon is de-agglomerated and a stable dispersion is produced. On the contrary, without Vanisperse LI, physically de-agglomerated carbon (achieved by mixing) in water becomes unstable as carbon-carbon attractive forces dominate. The result is a quick re-agglomeration of carbon. This is seen in Figure 6, as larger agglomerates are present even after they are sheared in pure water for several minutes, while smaller carbon particles persist when Vanisperse LI is used

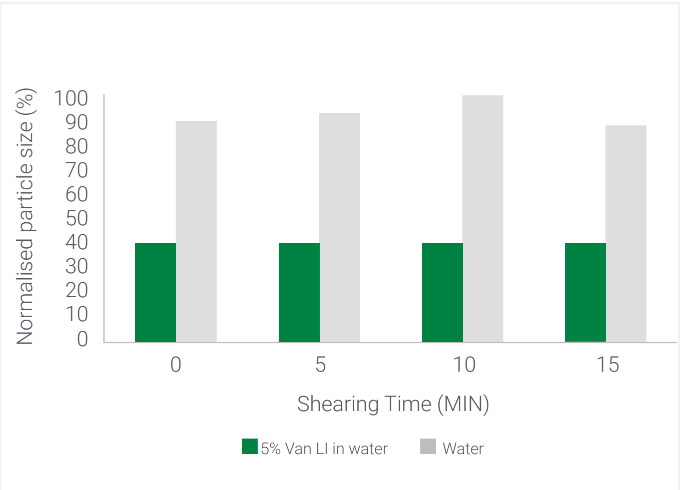

Figure 6. Particle size comparison of Super P Carbon in aqueous solution with and without Van LI after application of shear at 100 s^{-1} for different time periods. Particle sizes are normalised to the sample with the largest average particle size and are reported as a percentage of that maximum value.

The wettability of highly hydrophobic carbons can also be demonstrably improved by introduction of small quantities of Vanisperse LI. Vanisperse LI adsorbs strongly onto the carbon particles through surface affinic functional groups, whereas it's hydrophilic parts increase the wettability of the carbon surface and accelerates incorporation into aqueous media. Stabilisation of the dispersed particles from re-agglomeration is achieved by electrostatic and steric hindrance. In Figure 7 the wettability of Super P conductive carbon is displayed in aqueous solutions with Vanisperse LI doses ranging from 0-5 wt%. While poor wetting is observed for a 0 wt% system, rapid and extensive wetting is observed as a function of Vanisperse LI dosage.

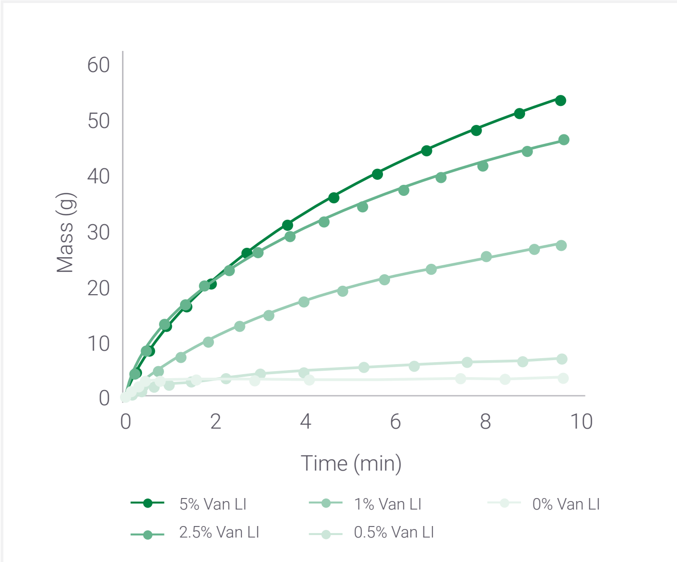

Figure 7: Wettability of Super P C45 with water and different doses of Vanisperse LI. Percentages of Vanisperse LI refer to concentrations in the solution.

Vanisperse LI provides a potent new offering to the field of Li-ion batteries. Vanisperse LI is a sustainable, low carbon additive for effective dispersion of carbons in battery electrode slurries and provides a potent new offering to the field of Li-ion batteries. It decreases slurry viscosity, improves carbon wettability and enables the preparation of higher-performing, less expensive Li-ion batteries.

REFERENCES

Video: Turbiscan – Formulation Dispersion Stability. https://www.youtube.com/watch?v=ImhP8ltrTZI

B.A. Armstrong, et al. J. Power Sources, 2022, 517, 230671.