

# bondwell™ cmc binders

## easy-to-use binders ensuring the integrity of your lithium ion batteries

### description

Ashland is the premier supplier of carboxymethylcellulose (CMC) binder technology for lithium ion battery anodes. Typically used in conjunction with styrene butadiene (SB) latex, naturally-derived Bondwell™ binders are renowned in the lithium ion battery industry for their usability, integrity and sustainability:

### usability

- fast dissolution for ease of processing
- high viscosity at low shear to prevent SB latex migration during slurry coating process
- low viscosity at high shear for easy mixing and coating
- compatible with industry standard materials including natural- and synthetic-graphite

### integrity

- high quality CMC to eliminate electrode defects
- superior capacity retention for cell integrity
- strong rate performance for power applications

### sustainability

Bondwell CMC binders contain at least 77% renewable carbon\*.

All Bondwell™ binders are fluorine-free, enabling use of water-based formulations for solvent-free, zero-VOC formulations.

## Ashland offers two standard grades of bondwell™ cmc binders:

**Bondwell™ BVH8 binder** has lower viscosity for easier processing and a lower degree of substitution (DS).

**Bondwell™ BVH9 binder** has higher viscosity for improved slurry stability and a higher degree of substitution (DS).

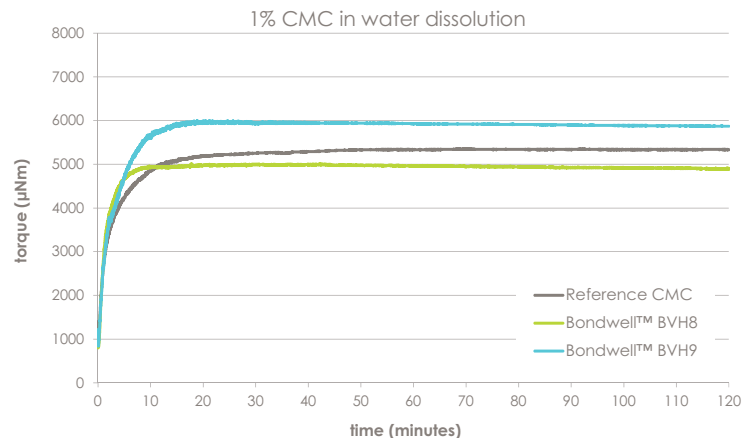
### Bondwell™ CMC anode binders

| product name              | degree of substitution (DS) | viscosity (1% solution, cPs) <sup>1</sup> | pH        | purity |
|---------------------------|-----------------------------|-------------------------------------------|-----------|--------|
| <b>Bondwell™ BVH8 CMC</b> | 0.80-0.95                   | 800 - 1,200                               | 6.5 - 8.5 | >99.5% |
| <b>Bondwell™ BVH9 CMC</b> | 0.90-1.05                   | 2,000 - 4,000                             | 6.5 - 8.6 | >99.5% |

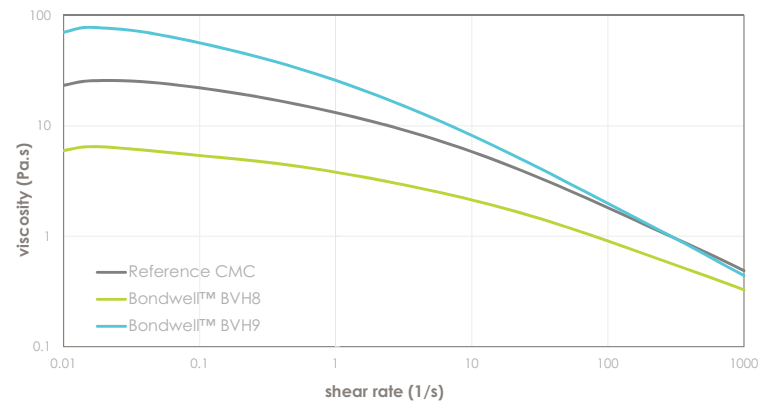
<sup>1</sup> Brookfield viscometer, LV type, spindle #4 at 30rpm at 25°C <sup>2</sup>purity, %, 100-(Na Glycolates + NaCl)

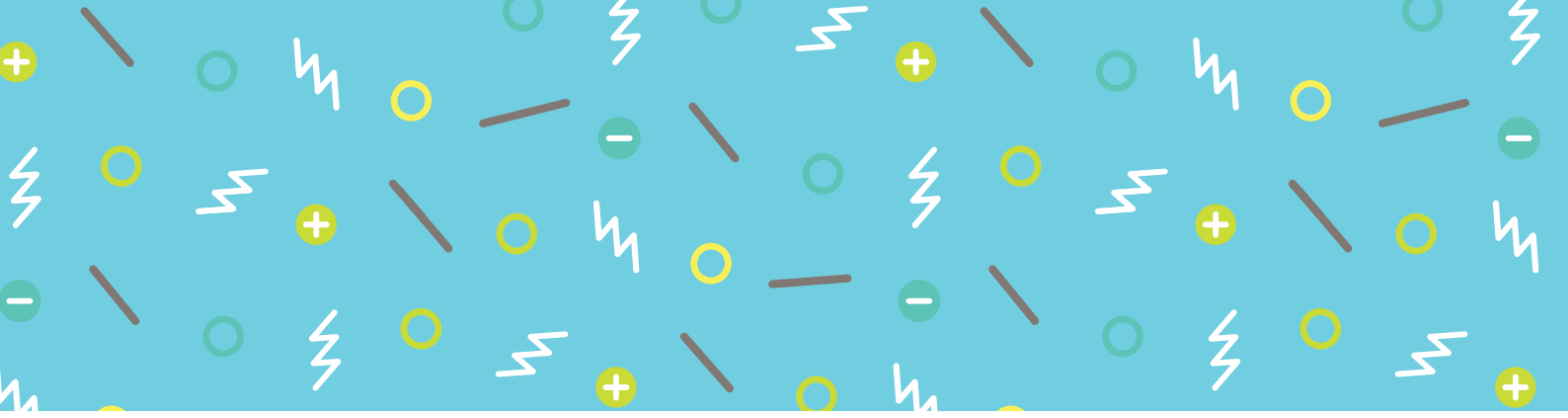
## bondwell™ cmc anode binders for usability

### Bondwell™ binders demonstrate fast dissolution for ease of processing



### Bondwell™ binders with (i) high viscosity at low shear rate for stability and (ii) low viscosity at high shear rate for easier mixing and coating





## bondwell™ cmc anode binders for integrity

superior quality of Bondwell™ binders to prevent cell defects (typical values)

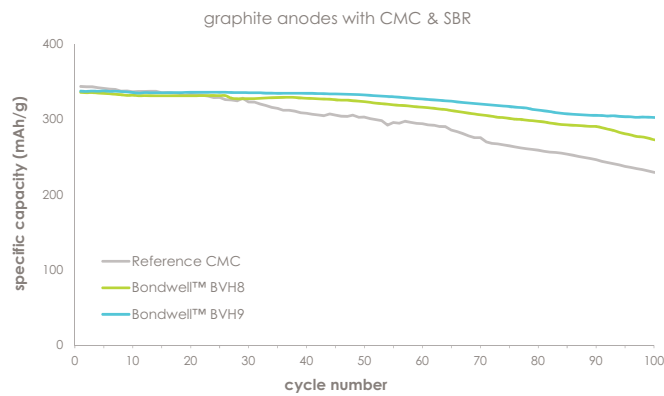
| product name       | moisture (%) <sup>1</sup> | particle size (D50 μm) <sup>2</sup> | number of gel particles <sup>3</sup> |
|--------------------|---------------------------|-------------------------------------|--------------------------------------|
| Bondwell™ BVH8 CMC | 4.7                       | 56                                  | 15                                   |
| Bondwell™ BVH9 CMC | 5.1                       | 51                                  | 19                                   |
| reference CMC      | 7.5                       | 101                                 | 21                                   |

<sup>1</sup> moisture analyzer

<sup>2</sup> laser diffraction particle sizer analyzer

<sup>3</sup> 1% solution of CMC, 100 μm thickness of wet drawdown, 5cmx5cm area

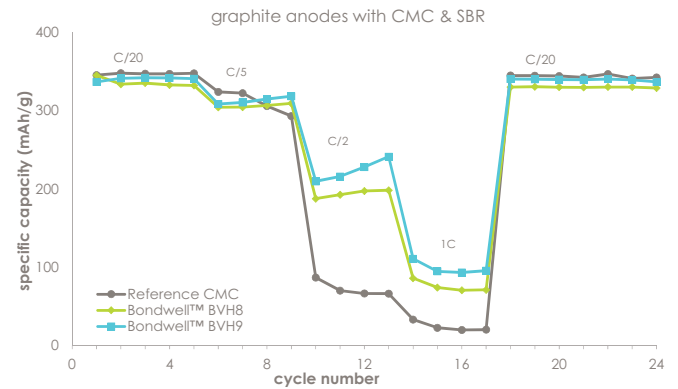
### superior capacity retention of Bondwell™ binders for cell integrity



**half coin cell:** Areal loading: ~ 5 mg/cm<sup>2</sup>; Density: 1.5 g/cm<sup>3</sup>; Electrolyte: 1 M LiPF<sub>6</sub> in EC/DEC/DMC.

**test condition:** Voltage cut-off 0.01V – 1.50V; Cycling rate: CC-CV at 0.2C-0.2C

### strong C-rate performance of Bondwell™ binders for fast charging and discharging



**half coin cell:** Areal loading: ~ 5 mg/cm<sup>2</sup>; Density: 1.5 g/cm<sup>3</sup>; Electrolyte: 1 M LiPF<sub>6</sub> in EC/DEC/DMC

**test condition:** Voltage cut-off 0.01V – 1.50 V; C-rates: CC-CC at 0.05C, 0.2C, 0.5C and 1C

## bondwell™ cmc binders for sustainability

Bondwell™ BVH9 CMC consists of 77 % renewable carbon\*

Bondwell™ BVH8 CMC consists of 78 % renewable carbon\*

\*These water-soluble polymers are derived from cellulose. The % renewable carbon has been calculated based on the cellulose and the average substituent level; it reflects the percentage of carbon from cellulose relative to the total amount of carbon in each of these products.

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