**L-Vis 510: STARCH ADHESIVES**

Measuring the dynamic viscosity of starch adhesives in the paper and packaging industry

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### Inline Starch Viscosity

Robust and accurate viscosity measurement under harsh process conditions is a challenging task made easy by Anton Paar’s unique, fluid dynamic inline viscometer, L-Vis 510. L-Vis 510 has a nanometer-resolution inductive displacement sensor which measures the deflection of a flexible cuff subjected to shear in a tapered gap. The wide gap tolerates suspensions with particle sizes up to a few hundred micrometers and allows thorough sample exchange. These features, along with excellent repeatability under sufficiently stable process conditions, open new opportunities for automatic viscosity-based process and quality control in demanding industrial processes.

![L-Vis 510 sensor](image)

### Starch Adhesives and Paper

Paper production is the largest non-food application for starches globally. In this application, starch is used in both sides of the paper manufacturing process, the “wet-end” and the “dry-end”.

In the “wet-end” process the starch is used as a binder for the paper fibers and inorganic fillers. Starch, together with some other additives, helps give the necessary strength to the paper. At the “dry-end” of the process, starch is used in the surface sizing and the paper coating process. The paper is rewetted or coated with a starch-based solution. This is done to additionally strengthen the final paper and to optimize the surface for printing properties.

### Starch Adhesives and Corrugated Cardboard

Corrugated cardboard is the second largest application of non-food starches globally. In this application, starch is used as an adhesive between the paper liners. Starch adhesives are either prepared cold from pre-manufactured starch adhesive powder or cooked together with caustic soda and borax to make an opaque glue. This adhesive is applied to the tips of the fluted paper layer which is accordingly pressed to another flat paper, called the liner. During drying under heat the starch adhesive gelatinizes, creating a strong adhesive for corrugated cardboard.

### Starch and Gypsum Wall Board

Starch is also used to manufacture gypsum wall board. Starches are added to the gypsum slurry which is then sandwiched between fairly heavy-weight top and bottom sheets of paper. The entire process is heated and cured to form the final rigid wall board. The starch acts as the glue for the cured gypsum rock and paper and gives rigidity to the final board.

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### Starch Adhesives Applications

- Paper
- Corrugated cardboard
- Gypsum wall board
- Paper bags, single and multi-wall
- Carton and case sealing
- Paper and board tube winding
- Laminated paper board
- Gummed tape and paper (wallpaper)
- Textile sizing
- Pharmaceuticals and personal care products
- Paints, inks and toners

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**Fig.1: L-Vis 510 sensor**
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Current Facilities Using L-Vis 510
The facilities in which L-Vis 510 is currently used include, but are not limited to, paper box and corrugated cardboard box and other corrugated cardboard manufacturers. L-Vis 510 is currently installed in adhesive applications for the corrugated cardboard industry in both the adhesive batch tank and the ring loop.

Corrugated Cardboard Production
In the production of corrugated cardboard, the starch adhesive is produced batchwise. Its quality is controlled via the final viscosity. L-Vis 510 is installed in the batch tank wall (or optionally in a bypass).

Benefits
The benefits of continuous inline measurement of viscosity during production are:

- Real-time, continuous quality control and assurance
- Repeatable adhesive batch quality
- Prevention of loss of product
- Reduction of production downtime
- Increased production and profitability
- Automation of the adhesive blending process

Application Data
Anton Paar has collected numerous data to determine the flow curve, the viscosity stability related to time and temperature, overall repeatability and how viscosity reacts to blending of different starch concentrations. Please see the following graphs for more detail.
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Laboratory Measurement

Fig. 5: Flow curve of a typical starch adhesive measured in the laboratory

Figure 5 demonstrates how the starch viscosity reacts to shear. At rest, the viscosity of the starch adhesive is over 2000 mPa.s and remains shear-thinning across the entire range. These values may vary depending on the individual application.

Inline Viscosity Measurement - Repeatability

The repeatability of the L-Vis 510 inline viscometer is also very stable and represents a difference of only 0.5 % of the measured value.

Inline Viscosity Measurement - Dilution Reaction

In order to verify the accuracy of the inline viscosity measurement with L-Vis 510 across a wide adhesive range a thorough dilution test of the starch adhesive was performed. Starting with a concentration of 16 % and repeatedly adding the same amount of water obtaining different concentrations of 15.6 %, 15.2 %, 14.8 % and 14.4 %. The batch quickly homogenizes and any change in viscosity is quickly seen.

Fig. 6: Repeatability of viscosity values measured by L-Vis 510

Fig. 7: Viscosity reaction to dilution measured by L-Vis 510
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Inline Viscosity Measurement – Ongoing Starch Adhesive Batch Blending

Starch is added to warm water, heated to 40 °C and caustic soda is added. Viscosity slowly increases to a target viscosity and a second starch and water addition is made. Once the final target viscosity is reached, borax is added to stop the starch conversion and retain the target viscosity.

![Graph: Batch production of cooked starch measured by L-Vis 510](image)

Technical Specifications

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity</td>
<td>1 to 50,000 mPa.s.</td>
</tr>
<tr>
<td>Typical accuracy</td>
<td>1 %</td>
</tr>
<tr>
<td>Typical repeatability</td>
<td>0.5 %</td>
</tr>
</tbody>
</table>

Conditions

- Sample temp. range: -5 °C to +200 °C
- Ambient temp. range: -20 °C to +40 °C
- Sample pressure range: 0 to 10 bar

Material

- Housing: stainless steel No. 1.4462, anodized aluminum
- Dimensions (LxWxH): 420 mm x 200 mm x 180 mm
- Weight: approx. 12 kg

Sensor

- Wetted parts: stainless steel No. 1.4462, diamond-coated SiC seal, Viton O-ring seal
- Installation dimensions (LxØ): min. 130 mm x 100 mm

Connection

- Anton Paar flange set incl. quick coupling
- DIN flange > 80 mm; ANSI flange > 3 in
- VARIVENT flange > 80 mm or 3 in

Operating terminal

- Display: 35 mm x 60 mm with optical pushbuttons
- Analog / digital communication
  - Analog output: 2 x 4 to 20 mA
  - Digital output: 1 x
  - Digital input: 1 x
- Fieldbus communication
  - Profinet
  - Profibus DP
  - Modbus TCP

Power supply

- DC 24 V 3.75 A

Degree of protection

- IP 65

Resources:

- “Stärkeeinsatz im Papier und deren Dosiereinrichtungen”; Roquette GmbH, Dr. Mano Wolf
- “Verbesserung der Papierfestigkeiten und der Prozesssicherheit bei der Oberflächenbehandlung von Wellpappehrpapieren durch spezifischen Stärkeaufschluss”; Papiertechnische Stiftung PTS, Birgit Kießler