Intrinsic Viscosity Measurements of PVC (Polyvinyl Chloride):

High-Throughput, Automated and Integrated

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Experiment Protocol

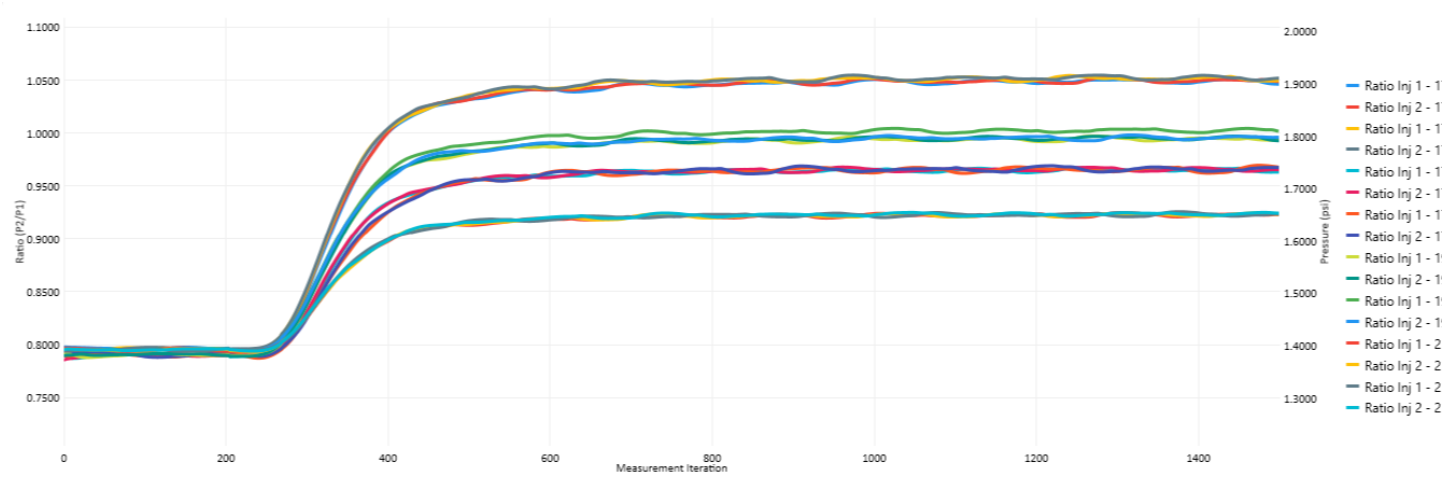
Overview: Four distinct commercial grades of PVC from a single manufacturing plant were dissolved in cyclohexanone at 70°C for 45 minutes. Each sample was prepared in duplicate, and after dissolution each sample IV was measured twice.

Sample Preparation workflow: Sample mass was recorded in the HaikuFlow software using a connected XS104 balance. Vials were placed in the sample preparation block with individually stirred positions after a PTFE stir bar and cap were added. No further user intervention was required. Dissolution solvent volume was calculated by the software and added to samples by the integrated syringe dosing pump. After a preset dissolution timer expired, samples were loaded and analyzed automatically.

Table 1: Sample Preparation, Dissolution and Temperature Settings Details

Application			Dissolution				Temperature (°C)		
Sample ID	Polymer	Solvent	Conc. (g/dL)	Stirring (min)	Settling (min)	Stir Speed (RPM)	Heater Block	Inline H/X	Visc Oven
1,2,3,4	PVC	cyclohexanone	0.200	45	10	300	70	29	30

Figure 1: P2/P1 Ratio Overlay of 8 PVC Resin Samples, 2 Injections Per Sample



Experiment Results

The four grades from IV = 0.74 dL/g to IV = 1.40 dL/g were clearly distinct, falling within their product grade ranges. The higher vial-to-vial variance between samples 3A and 3B are a result of inhomogeneity of the sample. The presence of gels in PVC grade 3 leads to a lower IV, since the gels are insoluble and do not increase the viscosity of the measured solution.

Table 2: Experimental Results for 5 Replicate Samples, 2 Injections Each

Sample Details			Viscosity Results				Repeatability	
Sample ID	**Conc. (g/dL)**	**Analysis Time**	RV1	RV2	**IV1**	**IV2**	**Within Vial % RSD**	**Vial-to-Vial % RSD**
1A	0.200	12:13:06	1.1602	1.1605	**0.7431**	**0.7443**	**0.0830**	**0.526**
1B	0.200	12:20:08	1.1623	1.1600	**0.7520**	**0.7421**	**0.6623**	
2A	0.200	12:27:43	1.2212	1.2230	**0.9990**	**1.0064**	**0.3679**	**0.454**
2B	0.200	12:35:18	1.2236	1.2211	**1.0092**	**0.9987**	**0.5200**	
3A	0.200	12:42:53	1.2574	1.2608	**1.1452**	**1.1588**	**0.5917**	**2.090**
3B	0.200	12:50:28	1.2691	1.2729	**1.1914**	**1.2065**	**0.6304**	
4A	0.200	12:58:03	1.3216	1.3210	**1.3943**	**1.3918**	**0.0882**	**0.262**
4B	0.200	13:05:38	1.3212	1.3234	**1.3927**	**1.4011**	**0.3028**	

Discussion

Intrinsic Viscosity (IV) is a primary critical-to-quality criterion determining whether an IV resin is appropriate for **packaging, pipe, blood storage bags, roofing membranes, car wraps** or **electrical insulation**. These IV specifications and tolerance ranges are the starting point for application development and processing conditions.

The low variance between **duplicate injections** shows complete **dissolution without degradation**.

The low variance between **replicate preparations** shows the **precision of the sample preparation**. Some PVC manufacturers dissolve their product in tetrahydrofuran (THF) because it breaks up the gels, providing a more consistent IV result from vial to vial, when gel-forming fractions are expected in the grade. Sample characteristics, historical precedent and site environmental health and safety (EHS) will inform the best practice for the determination of which solvent to use.

Each replicate injection was completed in around 3.5 minutes, giving a total analysis time of approximately 7 minutes for each sample. *Note: Customer requested longer analysis to match historical data.* Pairing these analysis times to the interval between sample preparation time ensures that results are not influenced by the position in the sample queue.

Insights into Integration: LIMS and ERP Connectivity

In our experience, stakeholders outside the laboratory often wait significantly longer for sample results to be reported than it takes to prepare and analyze samples. Sometimes hours, sometimes **over the weekend**.

With HaikuFlow software, this need not be the case. As each sample is completed, results are made available for import into your Laboratory Information Management System (LIMS) or Enterprise Resource Planning (ERP) software. System suitability checks, threshold setpoints and trend analysis all ensure that results outside of specifications are flagged for manager review before results are released from the software.

The Model 575 Intrinsic Viscometer
Generation 2

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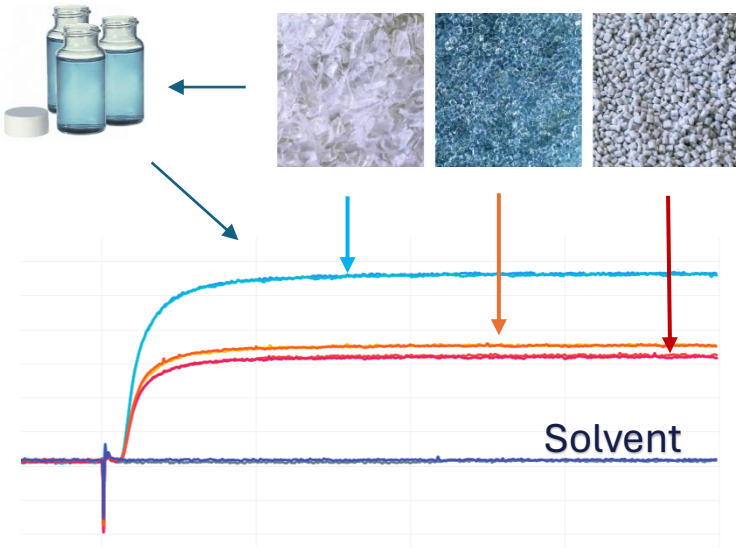
The Most Rapid and Reliable Measurement of Molecular Weight and Intrinsic Viscosity

Fully Automated Sample Preparation and IV Analysis According to ISO 1628 and ASTM D5225



Workflow Step	**Critical Advantages**
Sample Mass Determination	Guided Workflow with connected Analytical Balance
Solvent Dispensing	Fully Automated; no user interaction with solvents
Dissolution	24 Individually Stirred Autosampler Positions
Sample Analysis	Begins automatically after dissolution
Criterion	**Specification**
Viscosity Measurement Type	Dual Differential, Relative Viscosity, Forced Flow
IV Measurement Resolution	0.005 dL/g
Measurement Precision	Better than 0.2% RSD RV @ 0.800 dL/g
Shear rates	200-500 s^{-1} (typical, depending on application)
Sample Analysis Time	4-6 minutes per sample, includes duplicate injection
Solvent Compatibility	Organic, Aqueous, Acids, Halogenated
Temperature Range (Dissolution)	30°C to 160°C
Temperature Range (Analysis)	10°C to 160°C
Total Solvent Per Sample (prep + analysis + wash)	25mL
Integration, Compliance, Connection	LIMS/ERP, 21CFR part11, USB 2.0 / Windows 10

Viscometers for Plastics and Polymers
Designed and Manufactured in Houston, Texas
713-724-2890 | admin@haikuinstruments.com
www.linkedin.com/company/haiku-instruments