Hydrolyzed Corn Starch: Sustainable Alternative to Synthetic Styling Polymers for Clear Hair Gels

Delvalle, Cindy[1]; **Costanzo, Sam[2*]**; Joshi, Kinjal[3]; Johnson, Beth[2]; Lehman, Hannah[3]; Lan, Tian[3]

[1] Dow Personal Care, Seneffe, Belgium; [2] Dow Personal Care, Auburn, Michigan, USA; [3] Dow Personal Care, Collegeville, Pennsylvania, USA

* Sam Costanzo; 2200 W. Salzburg Rd., Auburn, MI 48611; +19894963265; samuel.costanzo@dow.com

Abstract

Background: Hair care consumers continue to demand products offering better performance, ease-of-use, and sustainability. Synthetic vinyl polymers such as Polyvinylpyrrolidone (PVP) are widely used styling agents, but sustainable hair fixatives have long been desired.

Methods: Hair gel compositions with hydrolyzed corn starch (HCS) up to 5% and carbomer up to 1% have been formulated. The turbidity in NTU (nephelometric turbidity units) was measured. Curl compression was measured by applying 0.3g of hair gel to 8-inch, 3g virgin medium brown hair tresses. Curl retention was measured at 25°C and 80% relative humidity over a period of 24 hours and at 25°C and 90% relative humidity over a period of 8 hours. A vapor absorption study was conducted under various humidity levels.

Results: The turbidity of the gel with HCS remains below 20 NTU at various temperatures (4, 20, 40°C). Hair gel with 5% HCS had comparable stiffness performance versus a comparative formula with PVP. Data indicated HCS containing hair gel can achieve greater than 95% curl retention performance at 80% relative humidity over 24 hours and 90% relative humidity over 8 hours. At 70% relative humidity PVP had higher water vapor absorption compared to HCS. The superior high humidity curl retention of HCS is attributed to lower water sorption.

Conclusion: Hydrolyzed corn starch (HCS) is a bio-based, cold water dispersible, film forming polymer which allows formulators to create clear compositions with superior hold and humidity resistance compared to synthetic fixatives such as PVP.

Keywords: hair; styling; natural; bio-based

Background

Hair care consumers today are increasingly focused on selecting products that contain natural ingredients without sacrificing performance. Attempts to introduce natural-based hair fixatives have often struggled with matching either the performance or optical clarity of synthetic materials. In addition to product performance, consumers are becoming increasingly focused on the concept of clean beauty. Clean beauty is focused on selecting sustainable ingredients that are safe for the environment and the consumer [1]. To address the needs and expectations of today's consumers, a novel Hydrolyzed Corn Starch (HCS) has been developed for use in hair styling applications. This HCS material is biodegradable, 100% naturally derived, and cold water dispersible.

Materials and Methods

1) Preparation of hair gels with Carbomer rheology modifier

Weigh 50g water and 3g glycerin into 400 mL beaker and stir at 500 rpm. Add Carbomer and continue stirring until all powder as completely dissolved. In a 150 mL beaker, add remaining water (40.9g). Add 0.1g Disodium EDTA to 150 mL beaker and stir at 400 rpm until Disodium EDTA has completely dissolved. Once Disodium EDTA is fully dissolved, add fixative polymer. Once solution is clear, add 1g Phenoxyethanol. Add mixture in 150 mL beaker to 400 mL beaker and stir for 5 min. Add 1g of Triethanolamine. Stir and adjust pH if necessary.

Table 1. *Hair gel formula.*

Ingredient	**INCI**	**Weight %**
Water	Water	90.9
Carbopol 980	Carbomer	1.0
VERSENE™ NA2 Crystals Chelating Agent	Disodium EDTA	0.1
Glycerin	Glycerin	3.0
Fixative Polymer		1.0-5.0
Phenoxyethanol	Phenoxyethanol	1.0
Triethanolamine	Triethanolamine	1.0

2) Preparation of hair gels with natural rheology modifiers

Formula 1 – Add water to beaker and begin mixing. Add Glycerin, HCS, Disodium EDTA, and Phenoxyethanol while continuing to mix. Add Hydroxyethylcellulose, mix for 5 minutes, then add Triethanolamine. Mix for 30 minutes. Add lactic acid and mix for 5 minutes.

Formula 2 – Add water and HCS to beaker and begin heating to 80°C while mixing. Once HCS is fully solubilized, add Disodium EDTA while continuing to heat to 80°C. After reaching 80°C, add Carrageenan rheology modifiers. After Carrageenan rheology modifiers are fully solubilized, remove from heat and allow formula to cool while continuing to mix. Once below 40°C, add Phenoxyethanol.

Table 2. *Hair gel formulas with natural rheology modifiers.*

Ingredient	INCI	Formula 1	Formula 2
Water	Water	91.87	94.40
MaizeCare™ Clarity Polymer	Hydrolyzed Corn Starch	3.00	3.00
Glycerin	Glycerin	3.00	
VERSENE™ Crystals Chelating Agent	Disodium EDTA	0.10	0.05
Phenoxyethanol	Phenoxyethanol	0.90	0.50
CELLOSIZE™ Hydroxyethyl Cellulose PCG-10	Hydroxyethylcellulose	0.80	
Genugel Carrageenan CG-130	Carrageenan		0.30
Genuvisco Carrageenan CG-131	Carrageenan		1.75
Triethanolamine	Triethanolamine	0.20	
Lactic Acid	Lactic Acid	0.13	

The styling formulas were analyzed using the following test methods.

- Clarity was measured using turbidimeter and results reported in Nephelometric Turbidity Units (NTU).
- Stiffness was measured using a MTT160 instrument from Dia-Stron Limited. Virgin brown hair tresses were treated with hair gel and allowed to dry overnight prior to testing. The peak force (stiffness) was measured by pressing the curled tress to 25% of its initial diameter.
- Curl retention was measured by treating 3g hair tresses with 0.3g of hair gel. The hair tresses were curled and allowed to dry overnight. After drying the tresses were placed in a humidity chamber at 25°C and 80% relative humidity for 24 hours.

3) Vapor absorption study

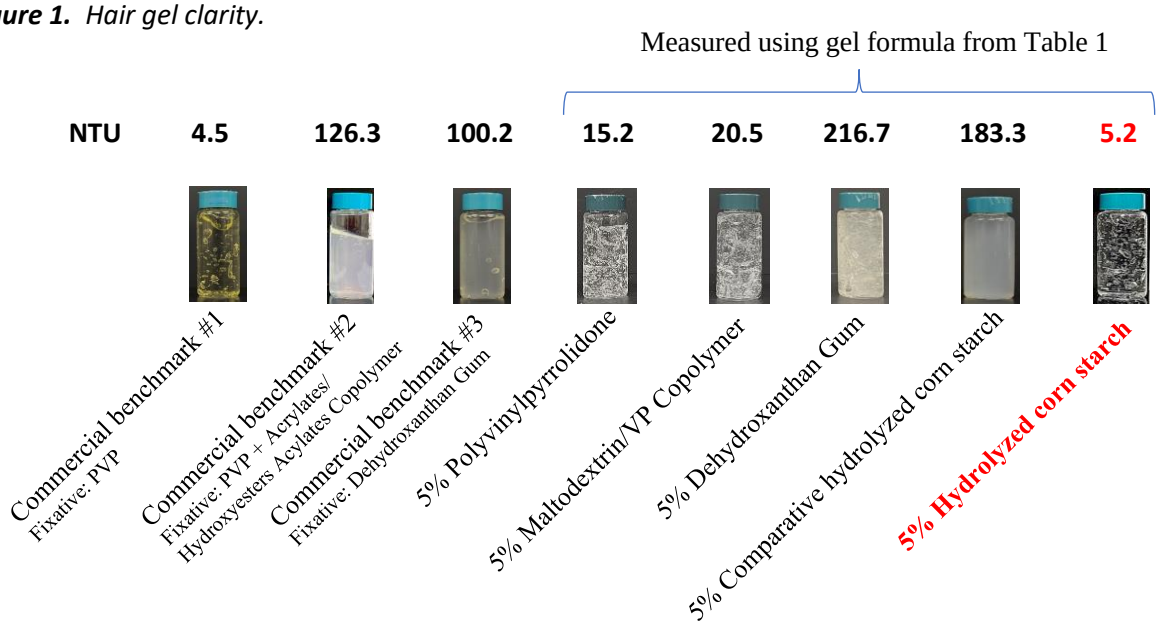
A vapor absorption study was run on neat HCS and neat PVP. Samples of each raw material were dried at 100°C for 5 minutes prior to testing. Samples were then placed in a humidity chamber for 4 hours. The percent increase in weight after exposure to a controlled humidity environment was measured at 10%, 30%, 50%, and 70% relative humidity, respectively.

Results and Discussion

1) Hair gels with Carbomer rheology modifier

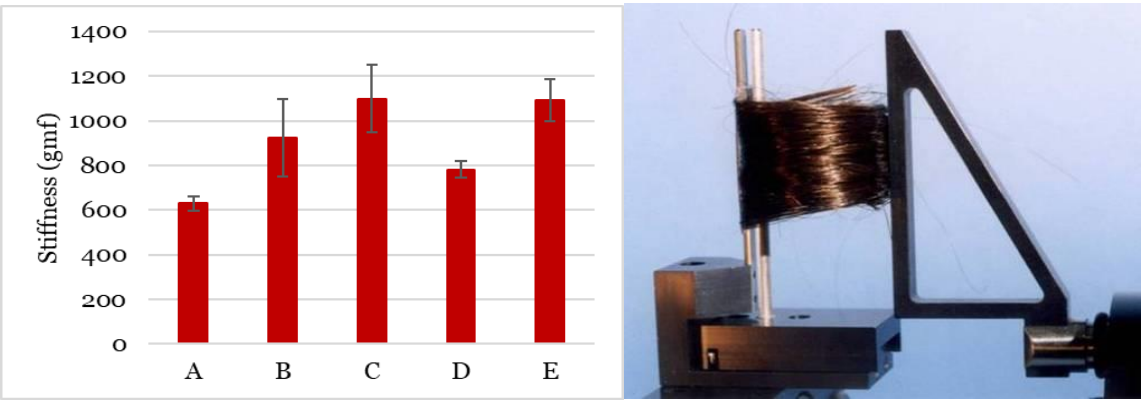
The hair gel formula in Table 1 was developed to benchmark the performance of HCS against other hair fixatives. Figure 1 reports the clarity of several different hair gels measured in Nephelometric Turbidity Units (NTU). HCS and comparative hair fixatives were evaluated at a 5% use level in the test formula from Table 1. Commercial benchmarks were also included in the study. Typically, hair gels with NTU values below 20 will appear clear to the human eye. Gels which use Polyvinylpyrrolidone (PVP) as the sole fixative (commercial benchmark #1 and test formula) have excellent clarity. Maltodextrin/VP Copolymer is a hybrid material that combines natural and synthetic chemistries. In the test formula, Maltodextrin/VP Copolymer was measured at 20.5 NTU, placing it right on the boundary of visual clarity. Dehydroxanthan Gum is a fully natural hair fixative; commercial benchmark #3 and the test formula demonstrate Dehydroxanthan Gum has poor visual clarity. The progressive loss in clarity when going from synthetic (PVP) to hybrid (Maltodextrin/VP Copolymer) to natural (Dehydroxanthan Gum) hair fixatives has long been a challenge for hair care formulators. HCS addresses the need to offer a fully natural hair fixative with clarity comparable to PVP.

Figure 1. *Hair gel clarity.*



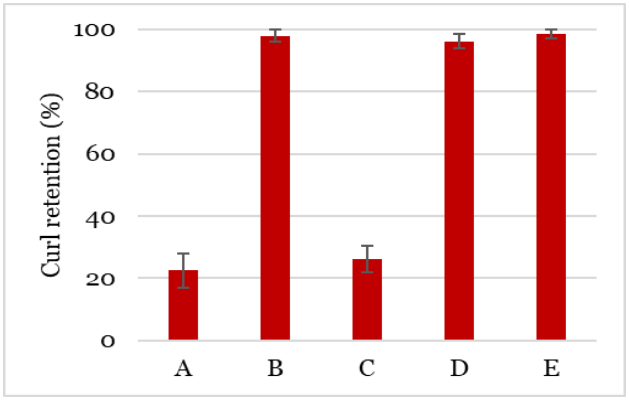
Hair stiffness results are reported in Figure 2. Increasing the use level of HCS from 1% to 5% led to an increase in the hair stiffness. This allows formulators to design formulas ranging from subtle to stiff hold depending on the concentration of HCS in the formula. There was no statistical difference in hold between HCS and PVP at 5% active concentration.

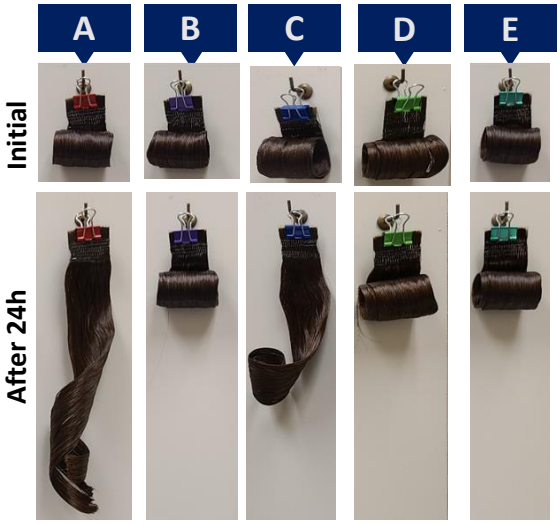
Figure 2. *Hair stiffness. A: Commercial hair gel with PVP fixative, B: Commercial hair gel with PVP and Acrylates/Hydroxyesters Acrylates Copolymer fixatives, C: Gel from Table 1 with 5% PVP, D: Gel from Table 1 with 1% HCS, E: Gel from Table 1 with 5% HCS.*



Curl retention results (25°C / 80% relative humidity) are shown in Figure 3. The tresses treated with HCS provided greater than 90% curl retention. The non-hygroscopic nature of HCS (see Figure 7) allows it to perform better under high humidity conditions.

Figure 3. *Curl retention after 24 hours. A: Commercial hair gel with PVP fixative, B: Commercial hair gel with PVP and Acrylates/Hydroxyesters Acrylates Copolymer fixatives, C: Gel from Table 1 with 5% PVP, D: Gel from Table 1 with 1% HCS, E: Gel from Table 1 with 5% HCS.*





2) Hair gels with natural rheology modifiers

In addition to the Carbomer rheology modifier used in the formula described by Table 1, HCS is also compatible with naturally derived rheology modifiers. Table 2 shows two additional hair gel formulas. Formula 1 is thickened with Hydroxyethylcellulose. Cellulose is a natural material and the most abundant biopolymer on Earth [2]. The grade of Hydroxyethylcellulose used in Formula 1 is 60% bio-based carbon by weight. Formula 2 is thickened with Carrageenan, which is a fully natural material. Both formulas give excellent curl retention after 24 hours at 80% relative humidity (see Figures 5 and 6).

Figure 4. *Formula 1 (left) and Formula 2 (right).*

Figure 5. *Curl retention for Formula 1 (25°C, 80% RH)*
A: Formula 1
B: Formula 1 without HCS
C: Commercial hair gel with Hydroxypropyltrimonium Hydrolyzed Corn Starch fixative
D: Commercial hair gel with VP/VA Copolymer fixative
E: Tress treated with water

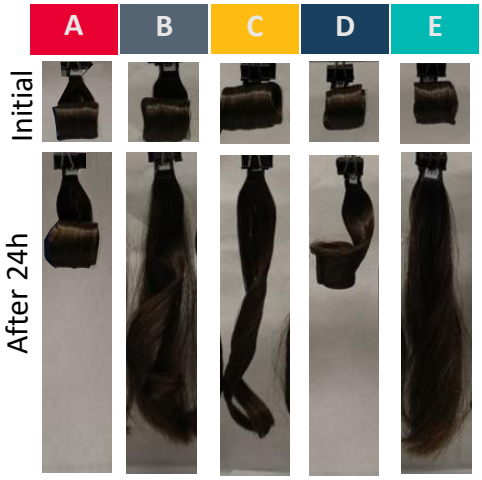
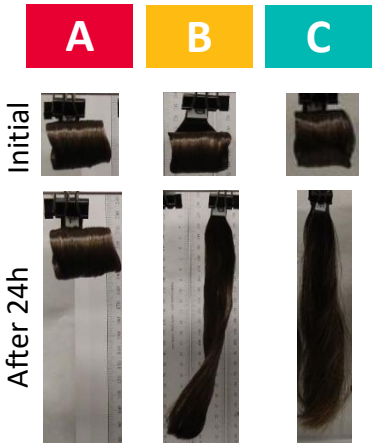


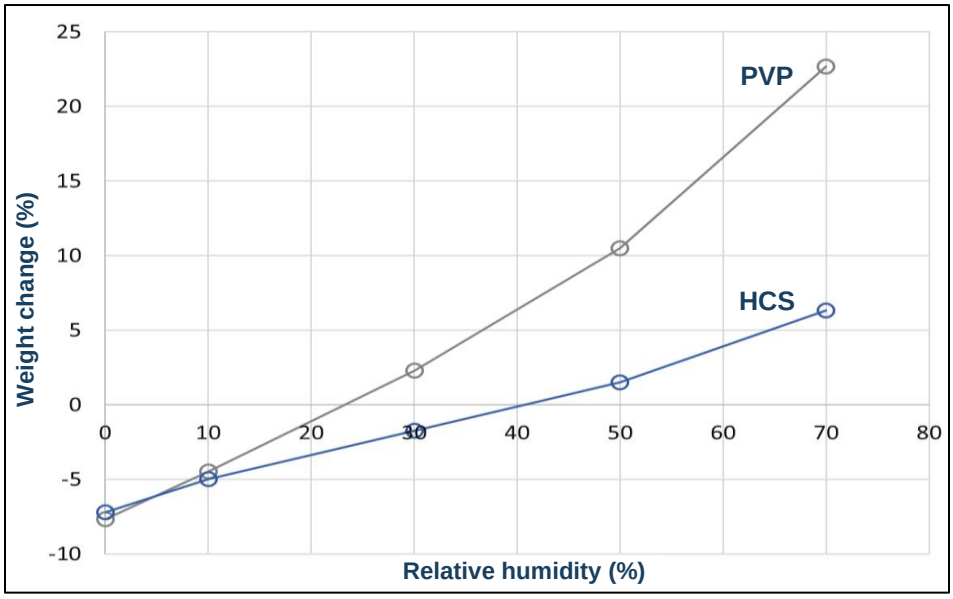
Figure 6. *Curl retention for Formula 2 (25°C, 80% RH)*
A: Formula 2
B: Commercial hair gel with PVP fixative
C: Tress treated with water



3) Vapor absorption study

The superior high humidity performance of HCS when compared to PVP is due to the non-hygroscopic nature of HCS. Vapor absorption results are shown in Figure 7. The HCS absorbs significantly less water vapor at high humidity conditions than PVP.

Figure 7. *Vapor absorption results.*



Conclusions

HCS is a 100% bio-based and readily biodegradable hair styling polymer, with excellent clarity in water-based formulas. HCS offers broad formulation compatibility and allows formulators to create clear styling aid compositions with superior hold and humidity resistance compared to synthetic fixatives like PVP. The hair care industry can now meet consumer expectations for a sustainability and performance in hair styling products.

References

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