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Sustainable Cellulose-derived Rheology Modifiers for Personal Care Applications

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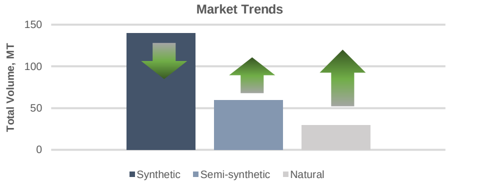
Home and Personal Care, Dow

Poster ID 613

Introduction:

Rheology Modifiers (RMs):

- Formulation stability
- Suspension of actives
- Product perception
- Desired texture
- Spreading, foaming, etc.

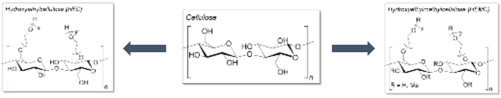



	Efficiency	Performance	Sustainability	
Synthetic	***	***	*	No biodegradability, very low biobased content
Semi-synthetic	**	***	**	Inherent biodegradability, mid biobased content
Natural	*	*	***	Readily biodegradability, high biobased content

Cellulose-derived HEMC polymer

- INCI: Methyl Hydroxyethyl Cellulose
- Powder, 100% active
- Inherent Ultimate biodegradability per OECD 302 testing
- No glyoxal added
- ~80% biobased content
- pH, electrolyte, surfactant tolerant

Materials & Methods:



Model formulations used in this study

Shampoo

Ingredient	Wt. %
Aqua (Water)	~87
Rheology Modifiers	0.45-1.0
Sodium Laureth Sulfate	9.0
Tetrasodium EDTA	0.2
Cocamide MEA	1.0
Cocamidopropyl Betaine	1.8
Phenoxyethanol	0.5
Citric Acid	q.s.
Aminomethyl Propanol	q.s.

1. Swell RMs in water
2. Add surfactants, heat to incorporate cocamide MEA
3. Cool and add preservatives
4. Equilibrate overnight and adjust to pH ~6

Conditioner

Ingredient	Wt. %
Aqua (Water)	~94
Rheology Modifiers	0.5-1.5
Cetearyl Alcohol	1.5
Tetrasodium EDTA	0.2
Glyceryl Stearate (and) PEG-100 Stearate	1.5
Phenoxyethanol	0.5
Citric Acid	q.s.
Aminomethyl Propanol	q.s.

1. Swell RMs in water
2. Heat and add fatty alcohol and emulsifier
3. Cool and add preservatives
4. Equilibrate overnight and adjust to pH ~6

Skin Lotion

Ingredient	Wt. %
Aqua (Water)	~68-73
Rheology Modifiers	0.4-0.8
Butylene glycol	2.0
PEG-100 Stearate	1.0
Glyceryl Stearate	3.0
Cetearyl Alcohol	1.0
Ceteareth-20	1.0
Caprylic/Capric Triglyceride	20.0
Phenoxyethanol	0.5
Sodium Chloride	4.0
Lactic Acid	4.0

1. Swell RMs in water phase
2. Heat both water and oil phases
3. Mix at high shear until emulsified
4. Cool and add preservatives
5. Adjust to pH ~7
6. Mix salt and lactic acid when present

Methods used in this study

Stability testing:
Optical appearance after 1, 2 and 4 weeks at room temperature and 50°C oven

Rheology testing:
TA Instruments DHR-3 rheometer with 60mm cross-hatched parallel plate and 60mm cone-and-plate geometries.
Testing done at 25 °C with default gap setting.
Amplitude sweep, (0.02 to 200% at 1 rad/s), oscillatory stress sweeps (0.2-200 Pa at 0.5 Hz), frequency sweep tests (0.01-100 rad/s at 2% strain) and shear rate sweeps (0.01 to 750 s^{-1}).
Shear rate sweeps fit to following equations:

$$\eta = \frac{\eta_0}{1+(K*\dot{\gamma})^n}$$

η_0 – zero-shear viscosity
η – shear rate index

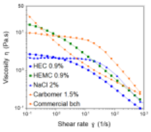
$$\eta = C(\dot{\gamma})^m$$

m – shear rate index

Suspension testing:
Fuchsia glitter was added to the top of a 3mL aliquot of shampoo formulation. Stability was assessed by the relative height of glitter after the vial is left at room temperature.

Results:

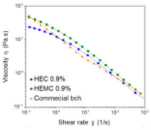
Shampoo formulation with HEMC:



	Thickening	Suspension
Against HEC	Higher	Higher
Against Salt	Similar/higher	Higher
Against Carbomer	Higher	Lower
Against Commercial benchmark	Lower	Similar
More efficient than carbomer and salt		

- Texture is similar than commercial benchmark – smooth flow, liquid-like
- Texture is better than Carbomer-only (jelly texture, solid-like)

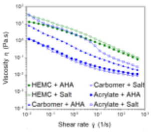
Conditioner formulation with HEMC:



	Thickening	Shear Thinning
Against HEC	Similar/Higher	Similar
Against Commercial benchmark	Higher	Similar/Lower
More efficient than HEC		

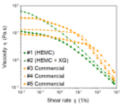
- Texture is similar for all formulations, HEC is more liquid-like, commercial benchmark is more solid-like
- Good viscosity at 3% solids vs. 6-10% in self-thickened conditioners
- great alternative for low-solids formulations

Skin cream formulations with HEMC:



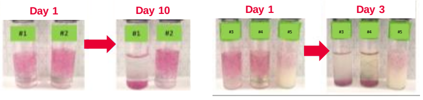
- Skin creams (0.6% HEMC) are softer and have lower viscosity than those with acrylate materials (0.4% Carbomer, 1.8% Acrylate Copolymer)
- Good pickup and easy spreading, no whitening or pilling
- Much better tolerance in formulations with low pH and high electrolytes
  - 4% lactic acid, 4% sodium chloride as model systems
  - Carbomer shows 10X-100X lower viscosity
  - Acrylate Copolymer shows 2X-75X lower viscosity
- Good option for challenging formulations

Shampoo formulations with enhanced suspension:



If superior suspension and high clarity are desired, best strategy is to blend with small amount of xanthan gum, XG (0.05-0.2%)

- Comparable viscosity as commercial benchmarks
  - Lower viscosity at high shear rates, slightly lower shear thinning
- Liquid-like texture and smooth flow
- Addition of xanthan gum significantly improved suspension (#2 vs. #1)
  - Even better suspension than benchmark shampoos



All tests were done at room temperature

Conclusions:

This new cellulose-based material (INCI: Methyl Hydroxyethyl Cellulose) is a suitable rheology modifier for a variety of personal care formulations: **Shampoo, body washes, conditioners, hydroalcoholic formats, skin creams and lotions**

- ✓ **Improved biodegradability and natural content vs. competitive cellulose ethers**
- ✓ **Compatible with surfactants, high pH and electrolyte tolerance**
- ✓ **No glyoxal, fast thickening – good for powder formats**
- ✓ **Superior thickening and suspension efficiency vs. HEC**
- ✓ **Enhanced surfactant compatibility, texture and emulsifying properties vs. natural gums**
- ✓ **Improved sustainability profile with slightly lower efficiency vs. acrylate polymers**
- ✓ **Blends with small amounts of xanthan gum improve suspension in surfactant formats without compromising texture, clarity and flow smoothness**

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References:

- ✓ Matic N, Bulmaga A, Davidson F, Zolghadri P, Chemaly A. (2021) Personal Care Ingredients: Global Market Analysis. Kline Database
- ✓ Muller S, Jebens A, Yang W, Inoguchi Y (2019) Specialty Chemicals Update Program: Cosmetic Chemicals. IHS Markit Report
- ✓ Rozman U, Kalcikova G (2021) The first comprehensive study evaluating the ecotoxicity and biodegradability of water-soluble polymers used in personal care products and cosmetics. Ecotox Environm Safety 228:113016
- ✓ Klemm D, Heublein B, Fink H-P, Bohn A (2005) Cellulose: Fascinating Biopolymer and Sustainable Raw Material. Angewandte Chemie 44, 22:3358-3393

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