I'm human

Hair styling gel formulation

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Every cosmetic chemist should learn how to make a gel, as it offers a great look and consumers tend to respond positively to this product form. The most common type of gel is the hair styling gel, so we'll explain its working mechanism and formulation. Hair styling gels are designed to keep hair in place by forming a rigid film that prevents movement. When applied initially, a well-formulated gel should be flexible but become stiffer as it dries. Styling gel ingredients include polymers like PVP or VP, which provide good hold while being water-soluble enough for easy wash-out from the hair. Carbomer is another key ingredient, acting as an acrylic polymer that becomes acidic when mixed with water and neutralized by TEA to create cross-linking within the polymer, forming a gel-like consistency. Other components include colorants, solubilizers, emollients, spreading agents, preservatives, and more. These ingredients may vary in their impact on product performance. Samples were treated with wet hair tresses, dried, curled, and hung vertically to evaluate the style's longevity under gravity's influence. Smart materials are revolutionizing the beauty industry by offering personalization, differentiation, and device combination capabilities, following their successful application in industries like fashion, automotive, and athletics [1]. Methylcellulose is a prime example of these innovative ingredients, which have been used in medical settings for years but are now being applied to hair gels. When heated with an external stimulus (a curling wand), methylcellulose undergoes a sol-gel transformation [2], similar to its body-temperature triggered transformation in medical contexts [2,3,4,5]. This smart material's hydrogels can be loaded with delivery components like drugs or cells, which transform upon injection into the human body [5]. Products featuring smart materials tend to feel more tailored to consumers, appealing to a broader market. Consumers appreciate the personalization these ingredients bring, as if their product has been reinvigorated [1]. In the beauty industry, this external stimulus is often provided by device combinations that support brand profits. The thermosensitive ingredient in this formulation is methylcellulose, which becomes heat-activated after blow-drying, locking styles in place when heated styling tools are used. As consumers apply high-temperature styling tools to hair coated with these smart gels, the storage modulus (G') increases with temperature, building a crystalline structure that solidifies the gel-like consistency [6,7]. The desire for device combinations is driven by consumer demand, as seen in products like Neutrogena's Light Therapy Acne Mask [8] and Clarisonic's ultrasonic brushes [9]. Consumers are seeking not only personalized products but also more sustainable alternatives. The potential of formulations combining methylcellulose and chitosan as natural ingredients offering smart gel benefits remains to be explored. As customers prioritize sustainability in their purchases, the beauty industry is driven by the clean beauty initiative, with consumers preferring naturally derived ingredients over synthetic ones. The use of chitosan and methylcellulose in combination is essential to maintain the shelf-life expectancy of cosmetics and general consumer goods. Although there has been extensive research on both ingredients separately, their combined effect remains understudied. This paper explores the potential benefits of blending these two biopolymers for hairstyling applications. Given that hair possesses a negative charge, a cationic polymer is required to ensure adhesion. Chitosan serves as this cationic polymer due to its ability to stick to the hair. Methylcellulose, on the other hand, acts as the thermoresponsive polymer responsible for locking hairstyles in place. Furthermore, frizz can be mitigated by applying a cationic polymer to counteract negative charges causing static and repulsion. For optimal results, proper spreadability is necessary for any hair product. As noted by Pingali et al., varying concentrations of chitosan yield a viscosity range between 10−1 and 101 Pa.s, which is ideal for various applications. Chitosan is commercially produced from chitin through the process of deacetylation using different salt concentrations. Its unique polysaccharide structure features an amino group attached to the C2 position in place of a hydroxyl group. Although chemically similar to cellulose, chitosan differs due to its additional acetyl amine group, imparting distinct attributes. Additionally, chitosan's greater intrinsic viscosity compared to other biopolymers with similar molecular weights contributes to its potential uses. The positive charge in chitosan makes it suitable for hair application, with the strength of this charge being dependent on the concentration of sodium hydroxide used during production. Chitosan is gaining interest within the consumer goods industry due to its clean beauty aspects, including biocompatibility and film-forming technology. It is also easily produced due to its abundance in nature as a byproduct of crustaceans, fungi, algae, and insects. As the only cationic polysaccharide found abundantly in nature, chitosan is uniquely suited for attachment to hair and skin needed by cosmetic or personal care goods. Methylcellulose, another biodegradable polymer used in this research, is also largely available and affordable. Despite its abundance, there has been a significant amount of research conducted on chitosan, but more work remains to be done to fully understand the potential benefits of combining it with other ingredients like methylcellulose. To boost the thickness, several studies have investigated how different chitosan concentrations affect the viscosity of the mixture [13,14,17,18]. Previous research has shown that varying chitosan levels from 0.25% to 2.5% exhibit consistent behavior where at low shear rates it remains a constant zero viscosity due to equal rates of disentanglement and fresh entanglements. However, in the power-law region, this behavior changes as the rate of entanglement occurs faster under higher shear rates than new entanglements can develop, leading to decreased viscosity [14]. Hwang et al. [14] observed a consistent trend where chitosan concentration increases with shear-rate-dependent viscosity. As the number of entanglements grows, the space for movement decreases, making it take longer to produce fresh entanglements again at increased shear rates. Consequently, Newtonian behavior disappears at lower shear rates as chitosan concentration rises [13]. To date, there have been no detailed rheological studies on chitosan. In developing a personalized hair gel system using chitosan as the natural thickener, a smart polymer was required to add personalization aspects. Methylcellulose was chosen for its prior research in various industries for its smart applications [23]. This polymer is widely used in food, ceramic, and pharmaceutical industries but less so in cosmetics. Its rheology depends on factors such as additives, temperature, pH level, molecular weight, polymer concentration, and ionic strength [23,24]. R. Moreira et al. [23] conducted a study on the steady and dynamic rheology of methylcellulose at temperatures below gelation. They examined methylcellulose gum at 25 °C with varying concentrations of polymers (7.5, 10, 15, and 20 g/L). As expected, increased polymer concentration led to increased viscosity at each shear rate. The plots showed a region with Newtonian plateau and another with shear-thinning behavior. At low and intermediate shear rates, the Newtonian plateau was observed, while at high shear rates, shear thinning behavior was noticed. The zero-shear rate viscosity increased exponentially with the addition of polymer concentration [23]. As temperature increases, shear rates rise accordingly, leading to lower viscosity. The viscoelastic behavior at low temperatures exhibited shear-thinning properties. However, the pH level had no impact on the rheology of methylcellulose when monitored. Research on smart gels, particularly those combining chitosan and methylcellulose, is scarce. A study on thermoresponsive smart gels in mascara applications led to the development of a hair gel formulation that emphasized eyelash curvature. The goal was to optimize long-term styling benefits by studying the combination of methylcellulose and chitosan. This paper explores the effects of varying concentrations on smart gel response and spreadability. The formulated smart hair gel consisted of deacetylated chitosan, methylcellulose (400 cPs viscosity), acetic acid (glacial), and distilled water. Chitosan requires an acidic environment to dissolve, achieved through a 0.1 M dilion mixture. Cellulise (10 g each) The spreadability and shear thinning behavior of each sample were evaluated by subjecting them to a flow sweep test at room temperature, with increasing shear rates ranging from 1 to 1000 s−1. Additionally, a temperature sweep test was performed to assess how the samples react to thermal stimuli, revealing changes in structure from fully amorphous to fully crystalline as the gel heats up. A visual hair curl drop test was conducted on ten smart gel formulations, using eleven identical hair tresses with the same thickness, color, and style. The results showed that the smart gels performed differently under various conditions, including varying concentrations of chitosan and methylcellulose. The rheological tests revealed a positive correlation between the amount of methylcellulose and the viscosity of the hair gel. However, the data also indicated that methylcellulose has a minimal impact on the viscosity of the samples at room temperature, whereas chitosan has a more significant effect. The findings suggest that the smart gels exhibit typical shear-thinning behavior, with increasing viscosity when subjected to higher shear rates. The test results will be useful in understanding how these products behave during application and helping to develop more effective hair styling agents. The thinner samples (6–10) exhibited lower spreadability due to their inability to lose viscosity over time, as confirmed by Figure 2. Increasing the overall concentration of chitosan within the solution at room temperature increased the viscosity of the sample, which was evident in Figure 3. The number of entanglements within the sample also increased with chitosan concentration, resulting in higher viscosity and shear stress. Sample 10, containing the highest concentration of chitosan, had the highest viscosity and an intense viscosity-shear rate relationship compared to any other samples tested. The viscosities of these samples decreased rapidly, with Sample 10's ending viscosity being quite different from its starting value, changing by as much as 7 Pa s. Sample 5 also exhibited this behavior, showing a rapid change in viscosity over a shear rate ranging from 1 to 1000 s−1. These samples had better spreadability factors compared to Samples 1 through 4, but thickness became an issue during the curl drop test, especially with Sample 10. When applied to hair, the smart gels were activated via heat sources such as blow drying. Application testing on both wet and dry hair concluded that application on wet hair resulted in a more evenly distributed product, while dry hair showed separation and clumping. As the temperature of the smart gel increased, it should start to thicken, indicating a crystalline and solid structure due to the thermoresponsive behavior of methylcellulose. Figure 4 and Figure 5 showed the effects of methylcellulose and chitosan concentration on the elastic behavior (G') of the smart gels versus increasing temperature. The values of G' should increase as the temperature of the gel increases, indicating solid-like behavior. For increasing methylcellulose concentrations, this relationship was noted in Figure 4 by the sharp increase in G' values for Sample 5 with the highest concentration of methylcellulose (2.75%). The thermal responsiveness of the system was enhanced as the methylcellulose concentration increased, suggesting that higher methylcellulose concentrations should result in a longer-lasting curl due to its more elastic solution and crystalline structure. When using chitosan on its own, it doesn't have temperature-sensitive properties, but when mixed with an acid like acetic acid, it forms a thick gel at room temperature. This means there's no clear link between increasing chitosan amounts and rising temperatures in Figure 5. The G' values for all samples increase as temperature increases, though the impact of chitosan concentration isn't linear. The transition temperature is influenced by how much chitosan interacts with methylcellulose. The more chitosan there is, the thicker the sample becomes, which can be useful in creating a smart gel that holds its shape but isn't too hard to remove from its container. Samples 6 and 7 were very thin because they had so little chitosan, making them unsuitable for marketing as gels with such low viscosity. On the other hand, Sample 10 was the thickest of all ten samples tested, making it difficult to remove from the vial. Eleven hair tresses were washed with SLS and then treated with various smart hair gels containing chitosan and methylcellulose. After being dried and curled with a curling wand, these tresses showed varying results in terms of curl retention over time. The samples with higher concentrations of methylcellulose tended to hold their curls better than those with lower concentrations. This can be seen in Figure 6a-c, where Sample 5 has the longest-lasting curl after 48 hours. This is likely due to its high thermal responsiveness, as shown by Figure 4, which results in a longer-lasting curl effect. In contrast, samples 1 through 4 experienced significant drops in curl over time compared to the control piece. The study examined the properties of smart hair gel formulations containing methylcellulose and chitosan. Samples with varying levels of methylcellulose (0% to 2.75%) and constant chitosan (0.25%) were tested for their effects on curl drop and longevity. Sample 2 showed the most significant drop in curl, while Samples 3, 4, and 5 experienced some hair separation at the ends due to high methylcellulose levels. Chitosan's ability to form a protective film around hair was also studied. As chitosan concentration increased, hair strands began to separate, particularly in Samples 9 and 10, which held their curls well but exhibited undesirable "crunchy" sensations. Sample 8 emerged as the best curl performer over 48 hours. The research aimed to develop personalized products combining the properties of methylcellulose and chitosan, inspired by the need for customized cosmetics. By exploring these smart materials, it's possible to create formulations that feel tailored to individual consumers while being produced on a large scale. The goal was to create a gel that's eco-friendly. Rheology testing showed how the gel behaves when applied to hair. A flow test was done at room temperature with increasing shear rates to see if it spreads easily but not too thin, as this would make it hard to apply. The more chitosan added, the thicker and harder it became, which is good for coating hair evenly. However, samples with varying methylcellulose levels were too thin and hard to apply. A temperature test showed how the gel responds to heat, with higher temperatures making it thicker but not ideal for all hair types. A curl drop test over 48 hours revealed that higher chitosan concentrations caused separation and crunchiness, but sample 8 had the best curls without these issues. This smart gel uses sustainable ingredients and can hold hairstyles in place for hours due to its thermoresponsive properties, making it a great alternative to other hair gels. Smart hair gel formulation may incorporate chitosan to address food allergens while enhancing aesthetic appeal, but further testing is needed due to limited resources. A controlled humidity chamber is required for thorough optimization, and a frizz test must be performed. The ideal sensory experience requires large-scale consumer study, which is beyond the scope of this research. Temperature analysis using DCS may reveal crystallization patterns. Research has been conducted to explore various skin-care tools and devices that can be used at home, as well as sustainable practices in the cosmetics industry (Bom et al., 2019). Additionally, studies have been published on deciphering frizz control hair care formulas (Abrutyn, 2013) and engineering rheological responses in chitosan-sophorolipid systems (Pingali et al., 2020). The properties of chitosan, a biodegradable polymer derived from crustacean shells, have also been studied in various contexts. The water-solubility of partially N-acetylated chitosans has been found to be affected by pH levels and chemical composition (Varum et al., 1994), while the rheological properties of chitosan solutions have been investigated (Hwang & Shin, 2000). Furthermore, research has explored the synthesis and characterization of hydroxyapatite/chitosan composites (Szatkowski et al., 2015) and the production and characterization of chitosan from shrimp waste (Hossain & Iqbal, 2014). The physicochemical, functional, and spectroscopic analysis of crawfish chitin and chitosan has also been investigated (Rout, 2001). In addition to these studies, research has also focused on the biodegradability and property characterization of methyl cellulose, including the effects of nanocompositing and chemical crosslinking (Rimdusit et al., 2008), as well as the rheological behavior of aqueous methylcellulose systems (Moreira et al., 2017). Overall, these studies demonstrate the importance of continued research in understanding the properties and applications of various biopolymers, including chitosan and cellulose derivatives. The use of smart thermoresponsive polymers has been explored in various applications related to cosmetics and biomedicine. Researchers have investigated the potential of these materials for their biostimulating effects on plant growth, antimicrobial properties, and sensory quality of food products. Studies have shown that chitosan, a biodegradable polymer derived from shrimp shells, can exhibit thermoresponsive properties, allowing it to change its viscosity in response to temperature changes. This property has been harnessed to create novel gels, hydrogels, and emulsions for cosmetic applications. Thermogelation of methylcellulose and alginate-methylcellulose gels have also been explored for their potential use as wound dressings or topical treatments. The rheological properties of these materials have been investigated to optimize their performance in various applications. Additionally, the development of shape-memory polymers has been reported, including cellulose acetate-based systems that can be recycled and reused. Temperature-responsive polymers have also been reviewed for their properties, synthesis methods, and potential applications in fields such as biomedicine and materials science. The antimicrobial activity of chitosan has been extensively studied, with various concentrations and formulations being explored for their effectiveness against different microorganisms. The use of chitosan-based composites for sensing applications has also been investigated, including the development of quartz crystal microbalance overlays. Overall, the research presented in this text highlights the potential of smart thermoresponsive polymers for a wide range of applications, from cosmetics and biomedicine to food processing and sensing technologies. The article discusses the properties, characterization, and transformation of biomass using ionic liquids. The process involves deacetylation of chitin into chitosan, which is used as a starting material for further processing. The study also examines the viscosity and storage modulus of various samples containing methylcellulose (MC) or chitosan at different concentrations and temperatures. The results show that increasing MC concentration leads to higher viscosity at low shear rates, while chitosan concentration has a similar effect but only up to a certain point. Additionally, the article presents the results of a curl drop test on hair samples treated with different compositions of MC and chitosan. The test involves taking photos of the hair samples at 0, 24, and 48 hours after treatment to assess their durability and stability. Overall, the study aims to understand the properties and behavior of biomass-derived materials in various applications and to develop new materials with unique properties for use in industries such as cosmetics or textiles. Curl drop test photos taken at varying time intervals after gel application show samples 6-10 alongside a control piece of hair. The images demonstrate the effects of the smart gel formulations over 48 hours. Table 1 provides details on the compositions of the smart gel samples, highlighting concentrations of chitosan and methylcellulose.