Physico-mechanical properties of topical formulations based on different polymers

Victor Hugo Pacagnelli Infante, Lívia Salomão Calixto, Patrícia M. B. G. Maia Campos
School of Pharmaceutical Sciences of Ribeirão Preto
University of São Paulo – Ribeirão Preto – Brazil
Email: pmcampos@usp.br

Abstract

The texture properties of formulations can be related to their sensory properties, and the correct choice of raw materials is an important tool to improve the sensorial properties of cosmetic formulations. This way, the objective of this study was to evaluate the physical-mechanical properties of different polymers applied in the cosmetic formulations and analyze how their concentration can affect these parameters. Twelve gel formulations were developed with four different polymers often used in cosmetic formulations in different concentrations: Ammonium Acryloyldimethyltaurate/VP Copolymer, Hydroxyethylcellulose, Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7, and Acrylates/C10-30 Alkyl Acrylate Crosspolymer. The system of physical-mechanical properties analysis was applied to characterize the texture profile in different parameters, as the cohesiveness and viscosity. The analysis of the obtained data showed that higher concentration of acrylate polymer is necessary to obtain a significant influence in the physical-mechanical parameters of the formulation. The parameter most affected by the hydroxyethylcellulose was the work of shear. The blend of Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7 showed the most pronounced alterations in the texture profile. Ammonium Acryloyldimethyltaurate/VP Copolymer did not alter the physico-mechanical properties of the formulations studied and Acrylates/C10-30 Alkyl Acrylate Crosspolymer altered the texture parameters only when used in the lowest and the highest concentrations in the formulations. Finally, the type of polymers could result in formulations with different physico-mechanical properties, reflecting its performance when applied on the skin.

Keywords: texture profile, cosmetic formulations, polymers

Resumo

As propriedades de textura das formulações estão relacionadas com as propriedades sensoriais e a escolha correta das matérias-primas é uma importante ferramenta para melhorar as propriedades sensoriais das formulações cosméticas. Dessa forma, o objetivo deste estudo foi avaliar as propriedades físico-mecânicas de diferentes polímeros utilizados em formulações cosméticas e analisar como a concentração dos mesmos pode afetar estes parâmetros. Doze formulações de gel foram desenvolvidas com quatro diferentes polímeros altamente utilizados em formulações cosméticas em diferentes concentrações: Acryloyldimethyltaurate de Amônia/Copolímero VP, Hidroxietilcelulose, Poliacrilamida (e) Isoparafina C13-14 (e) Laureth-7 e Acrilatos/Acrilato de Alquil C10-30Crossopolímero. O sistema de análise das propriedades físico-mecânicas foi utilizado para caracterizar o perfil de textura em diferentes parâmetros, como coesividade e viscosidade. A análise dos dados obtidos mostrou que é necessária uma maior concentração de polímero de acrilato para obter uma influência significativa nos parâmetros físico-mecânicos da formulação. O parâmetro de textura mais afetado pela hidroxietilcelulose foi o trabalho de cisalhamento. O blend de Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7 mostrou alterações mais pronunciados nos perfis de textura. Ammonium Acryloyldimethyltaurate/VP Copolymer não alterou as propriedades físico mecânicas das formulações e o polímero Acrylates/C10-30 Alquil Acrilato Crosspolymer alterou essas propriedades somente quando foi usado nas menores e maiores concentrações. Por fim, o tipo de polímero pode resultar em formulações com diferentes propriedades físico mecânicas, o que reflete na performance das mesmas quando aplicadas na pele.

Palavras-chave: perfil de textura, formulações cosméticas, polímeros

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Introduction

Sensory analysis is very important during the development of cosmetic formulations. Formulations with good sensory properties can represent a better reception by the consumer and, consequently, adherence to treatment. Quantitative Descriptive Analysis (QDA®) and the Spectrum™ Descriptive Analysis (SDA) are two methods to evaluate the sensorial properties of topical products, however, these methods require time and a trained panel. (1, 2) For this, instrumental measurements can be chosen as an alternative, but it is necessary to study which methods are effective and useful for the proposed analysis. Such analyses can help the pharmaceutical and cosmetics companies to save time and money. (3, 4)

During the development of topical formulations, information about how the raw material(s) can influence the final product is very important. Many parameters can be modified, such as concentration of ingredients, protocol, and combination of raw materials. Such modifications can improve the physical characteristics of the formulation, which could reflect on the sensory properties. (5, 6)

This way, the correct choice of raw materials is essential to obtain an exceptional topical formulation, but more than quality, it is necessary to have information about how it can improve the physical-mechanical quality of the topical formulation. (7, 8) Different types of polymers are used to create gel formulations or to improve the rheological characteristics on other cosmetic formulations, such as emulsions. (9) In this context, knowledge about how they can influence the physical-mechanical characteristics is a good way to solve challenges in pharmaceutical and cosmetic technology. (10)

The objective of this work was to study the physical-mechanical properties of different polymers applied in the topical formulations and to analyze how the polymer concentration can affect these properties using a system of physical and mechanical properties analysis.

Material and Methods

Developed formulations

Twelve gel formulations with four polymers in different concentrations were developed (Table I). The polymer concentrations were selected by the minimum, medium and maximum values of concentration use provided by the data sheets. Hydroxyethylcellulose (HEC, Natrosol® - Ashland) and the Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7 mixture (SEPIGEL 305™

Introdução

Para desenvolver uma formulação tópica, é necessário obter uma fórmula estável e com um sensorial agradável. Uma formulação com alto desempenho sensorial significa uma boa recepção pelo público, aderência ao tratamento e demanda pelo produto. A Análise Descriptiva Quantitativa e a Análise Descritiva do Spectrum™ (SDA) são dois métodos para avaliar as propriedades sensoriais de produtos tópicos. No entanto, esses métodos exigem tempo e um painel treinado. (1, 2) Para isso, as medidas instrumentais podem ser escolhidas como uma alternativa, mas é necessário estudar quais métodos são eficazes e úteis para a análise proposta. Isso representa uma melhoria na indústria farmacêutica, pois poderia ajudar a economizar tempo e dinheiro. (3, 4)

Durante o desenvolvimento de formulações tópicas, informações sobre como a matéria-prima pode influenciar o produto final são muito importantes. Muitos parâmetros podem ser modificados como concentração de ingredientes, protocolo e combinação de matérias-primas. Pode melhorar as características físicas da formulação, o que poderia refletir nas propriedades sensoriais. (5, 6)

Desta forma, a escolha correta das matérias-primas é essencial para obter uma formulação tópica excepcional, mas mais do que qualidade, é necessário obter informações sobre como melhorá-la. (7, 8) Diferentes tipos de polímeros são usados para criar formulações em gel ou para melhorar as características reológicas em outras formulações cosméticas. (9) Neste contexto, o conhecimento sobre como eles podem influenciar as características físico-mecânicas é uma boa maneira de resolver dificuldades na tecnologia farmacêutica e cosmética. (10)

O objetivo deste trabalho foi estudar as propriedades físico-mecânicas de diferentes polímeros utilizados na indústria farmacêutica e analisar como a concentração pode afetar esses parâmetros por meio de um sistema de análise de propriedades físicas e mecânicas.

Material e Métodos

Desenvolvimento de formulações

Foram desenvolvidas doze formulações de gel com quatro polímeros em diferentes concentrações para analisar os efeitos dos mesmos nas propriedades de textura (Tabela I). As concentrações dos polímeros foram selecionadas pelos valores mínimo, médio e máximo de concentração fornecidos pelas fichas técnicas. Para
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...were applied in the minimum concentration of 2% based on the sensitivity of the Texture Analysis system to perform the physical-mechanical analysis. All formulations were developed considering a minimal variation on their components to avoid interferences in the physical-mechanical properties results. To confirm their stability, an aliquot of 5 grams of each formulation was weighed and centrifuged at 3000 rpm, 3 cycles of 30 minutes each (CentriBio) at room temperature. The polymers used in the gel formulations were Ammonium Acryloyldimethyltaurate/VP Copolymer (Aristoflex AVL® - Clariant) and HEC. Each was weighed and prepared in a volume of water sufficient to obtain 100 g of formulation. Preservatives (ChemyUnion) were weighed and dissolved in the required amount of propylene glycol (Synth) and incorporated in the formulation. For HEC, the polymer solution was heated to 60 °C in a hot plate (Fisaton) and stirred until the polymer chain was constructed.

Table 1/Tabela 1 – Formulation composition / Composição das Formulações

| Polymer / Polímero | INCI Name / Nome INCI | Conc. 1 | Conc. 2 | Conc. 3 |
|--------------------|------------------------|--------|--------|--------|
| Aristoflex® AVC | Ammonium Acryloyldimethyltaurate/VP Copolymer | 0.5% | 2.5% | 5.0% |
| Natrosol® 250 HR/HHR | Acryloxethylcellulose Hidroxiétilcelulose | 2.0% | 3.0% | 5.0% |
| SEPIGEL® 305 | Polyacrylamide (e) Isoparafina C13-14 (e) Laureth-7 | 2.0% | 3.0% | 5.0% |
| CARBOPOL® ULTREZ 20 | Acrylates/C10-30 Alkyl Acrylate Crosspolymer | 1.0% | 4.0% | 8.0% |

Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7 and Acrylates/C10-30 Alkyl Acrylate Crosspolymer (AAAC, Carbopol - Lubrizol) were weighed and dissolved in a volume of water sufficient to obtain 100 g of formulation. Preservatives (ChemUnion) and EDTA (LabChem) were weighed and dissolved in the required amount of propylene glycol and incorporated into the formulation. The pH was then adjusted to 6.0 using AMP 95 (ANGUS Chemical) to have the formation of polymeric netting. All the formulations utilized 3% of propylene glycol (Synth) and sufficient concentration of preservative (0.8%).

Polyacrilamida (e) Isoparafina C13-14 (e) Laureth-7 e Acrilatos/C10-30 Álcool Acrilato Crosspolymer (AAAC, Carbopol - Lubrizol) foram pesados e dispersos em quantidade suficiente de água para obter 100 g de formulação. Os conservantes e EDTA (LabChem) foram solubilizados na quantidade requerida de propilenoglicol e incorporados na formulação. Acrilatos / C10-30 Acrilato Alquil Crosspolymer (AAAC, Carbopol - Lubrizol) foram pesados e dispersos em quantidade suficiente de água para obter 100 g de formulação. Os conservantes (ChemUnion) e EDTA (LabChem) foram solubilizados na quantidade necessária de propilenoglicol e incorporados à formulação e depois disso, o pH foi ajustado para 6,0 usando AMP 95 (ANGUS Chemical) para se obter a formação do polímero.

Todas as formulações utilizaram 3% de propilenoglicol...
Texture Analysis

For the texture analysis, the system of physical and mechanical properties analysis, a model TA.XT/Plus 50 instrument (Stable Microsystems, United Kingdom), was utilized. The method used to determine the texture consisted of inserting a probe in the analytical sample, two consecutive times, with a defined speed and depth, leading to pre-defined recovery period between the end of the first compression and the beginning of the second one. From the resulting graph of force (N) per time (t) the following parameters were obtained: cohesiveness, consistency, firmness, viscosity index and work of shear. For work of shear the height was 25 cm and the probe velocity 30 mm/s. The texture analyses were established with 100 mm of height and 30 mm/s of velocity.

Figure 1/ Figura 1 – Influence of polymer concentration on cohesiveness, firmness and work of shear, where (*) means 0.01<p<0.05; (**) means 0.001<p<0.01, and (***) means p<0.001. / Influência da concentração de polímeros na coesão, firmeza e trabalho de cisalhamento, onde (*) significa 0.01<p<0.05; (**) 0.001<p<0.01 e (***) p<0.001.
Statistical Analysis

The data obtained was compared by Kruskal and Wallis and a Dunns posttest (α=0.05), except when the data had a normal distribution, in the cases of consistency [Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7], work of shear [HEC and Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7], and viscosity [Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7]. In latter cases, the one-way analysis of variance test was used and the Tukey posttest to compare the concentrations.

Results and Discussion

The Ammonium Acryloyldimethyltaurate/VP Copolymer is characterized as an anionic gel, easy to work with because is pre-neutralized and stable. It can also be used as a thickening agent in topical and cosmetic formulations, such as emulsions. The concentrations of 0.5% and 5.0% showed high significant difference for all parameters, but cohesiveness presented the lower statistical difference. Thus, this polymer needs a greater concentration change to present a significant contribution on the physical-mechanical parameters analyzed. The Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7 is pre-neutralized and forms inverse emulsion instantly by simply adding water. With this formulation we observed a linear result with the increase of its concentration on the physical-mechanical properties. This could be more related with the inverse emulsion characteristic, since its composition can form globules, not only polymeric networks. (11)

For AAAC, it was observed that to obtain significant changes on physical and mechanical characteristics it was necessary to use eight times more of this polymer. Cohesiveness, firmness, and work of shear are properties with similarities as they are closely related to the polymer structure of the selected material. It is important to highlight the influence of cohesiveness and work of shear on the performance of the formulation on the skin. Thus, they can impact the sensorial properties of the formulations. (12) This way, polymers with higher differences between the concentrations can have the most influence on sensorial characteristics and acceptance of topical formulation. This can be observed in the AAAC, for example, with a good correlation between these three parameters. It is interesting to highlight the impact of the type of the polymers, not just the variation on concentration, in the work of shear. This result can be observed especially de 25cm e a velocidade de 30 mm/s. As análises de textura foram estabelecidas com 100 mm de altura e 30 mm/s de velocidade.

Análise Estatística

De acordo com a distribuição amostral dos dados obtidos, os mesmos foram analisados pelo teste não paramétrico de Kruskal e Wallis e Dunn (α = 0,05) e pelo teste paramétrico one-way de análise de variância e o teste complementar de Tukey para comparar as concentrações quando os dados que apresentaram distribuição normal para os dados dos parâmetros de consistência [Poliacrilamida (e) Isoparafina C13-14 (e) Laureth-7], trabalho de cisalhamento [HEC e Poliacrilamida (e) Isoparafina C13-14 (e) Laureth-7] e viscosidade [Poliacrilamida (e) Isoparafina C13-14 (e) Laureth-7].

Resultados e Discussão

O polímero Amônio Acryloydimetethyltaurate/VP Copolymer é caracterizado como um gel aniónico, sendo de fácil preparação por ser pré-neutralizado e estável. Também pode ser utilizado como agente espessante em formulações cosméticas, como as emulsões. As concentrações de 0,5% e 5,0% apresentaram diferença significativa para todos os parâmetros, porém, o parâmetro a coesividade apresentou a menor diferença estatística. Dessa forma, foi possível observar que este polímero necessita de maior variação em sua concentração para influenciar significativamente os parâmetros físico-mecânicos analisados.

Poliacrilamida (e) C13-14 isoparafina (e) Laureth-7 é pré-neutralizada e forma uma emulsão inversa instantaneamente simplesmente adicionando água. Nesta formulação, observamos um resultado linear com o aumento de sua concentração nas propriedades físicas-mecânicas. Poderia estar mais relacionado com a característica de emulsão inversa, já que em sua composição é possível observar a formação de glóbulos e não apenas redes poliméricas. (11) Para o polímero AAAC observou-se que, para obter mudanças significativas nas características físico-mecânicas, foi necessário utilizar oito vezes mais desse polímero.

Coesão, firmeza e trabalho de cisalhamento são propriedades com similaridades, pois estão intimamente relacionadas à estrutura do polímero do material selecionado. É importante destacar a influência da coesão e do trabalho de cisalhamento no desempenho da formulação sobre a pele. Assim, podem impactar nas propriedades sensoriais das formulações. (12) Desta forma, polímeros com maiores diferenças entre as concentra-
between the formulations with high polymer concentration. Likely this characteristic is highly correlated with the firmness. Both the work of shear and firmness presented significant difference not just between the different concentrations, but also the type of polymer.

The increase in polymer concentration results in an increase in the physical and mechanical parameters of formulations. However, in the formulations based on HEC, the firmness parameter was the most influenced by the polymer concentration, differently than in the other formulations. For the others, the work of shear was the most affected, showing a more direct influence with the sensorial. (12, 13) Firmness is a feature related to the structure of the formula itself, so increases in HEC concentrations will mainly influence how the polymeric formula behaves when stored, for example (Figure 1).

Viscosity and consistency are properties related with the structure of the formulation. (14) This way, increases on concentration of certain polymers as HEC, for example, can result more structured formulations. This information is important for the stability of the final formulation. Both viscosity and consistency increase linearly with the increase of polymer concentration. Thus, the physico-mechanical characteristics end

![Figure 2](image-url) – Influence of polymer concentration on viscosity and consistency, where (***) means p<0.001. / Influência da concentração de polímero na viscosidade e consistência, onde (***) significa p<0.001
up behaving in the same way with the increase of the concentrations of the studied polymers (Figure 2). The structure of polymeric material has an important role on these characteristics. Polymers with a cyclic lateral chain, AAAC, had less improvement of viscosity and consistency with the increase of polymer concentration. This polymer has a cyclic amide on its lateral chain, which means that the total volume of polymer will be more representative and can change the structural properties of formulations as viscosity. The carbomer AAAC was different because its lateral chain does not have a cyclic chain, so it was possible to create a better cross-linked 3D-structure, with a more compact formulation, with a large increase on physical-mechanical parameters with lower concentrations of polymer. (15-17)

HEC has a smaller lateral chain when compared to the other polymers cited previously. For this reason, when the concentration is increased 2.5 times, the results of viscosity and consistency are the same as for the AAAC when it was increased 8 times. (18-21)

It was possible to observe statistical differences between all the formulations with the higher polymer concentrations. However, in the lower concentrations significant differences between the formulations with different polymers were not found. Thus, regarding consistency, a significant difference (p<0.05) was found between the minimum values of HEC, AAAC, and Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7, likely because Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7 is an inverse emulsion. In Figure 2, it is possible to observe that increases in concentration of Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7 did not greatly influence consistency. Jones, Woolfson, and Brown (1997) (22) demonstrated in their study that cohesiveness decreased with the increase of the polymers’ concentration. In our study, this property had a non-significant increase to HEC and Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7, however, for Ammonium Acryloyldimethyltaurate/VP Copolymer and AAAC it was possible to observe a significant increase (p<0.05) with the increase of polymer concentration. Additionally, the higher concentration of AAAC was significant different than the other polymers (p<0.001) in the higher concentrations. It is important to highlight that in their study, HEC was combined with chlorhexidine, which could modify this parameter. Calixto and Maia Campos (2017) (12) showed in their study that the relationship between firmness and cohesiveness was perfect and positive, that is, if one of these parameters increases the other will also increase proportionally. In our study it happens with all formulae of the concentration of the polymers. Assim, as características físico-mecânicas acabam se comportando da mesma forma com o aumento das concentrações dos polímeros estudados (Figura 2).

A estrutura do material polimérico tem um papel importante nessas características. Polímeros com cadeia lateral cíclica, Acryloydimethyltaurate de Amônio/ Copolímero VP, tiveram menor melhora da viscosidade e consistência com o aumento da concentração de polímero. Este polímero tem uma amida cíclica na sua cadeia lateral, o que significa que o volume total de polímero será mais representativo e pode alterar as propriedades estruturais das formulações como viscosidade. Para o carbômero AAAC foi diferente porque sua cadeia lateral não possui uma cadeia cíclica, sendo possível estruturar uma melhor estrutura 3D reticulada, tendo uma formulação mais compacta, com grande aumento nos parâmetros físico-mecânicos com menor concentração de polímero. (15-17)

A HEC possui uma cadeia lateral menor quando comparada aos demais polímeros citados anteriormente. Por essa razão, quando a concentração aumenta 2,5 vezes, os resultados de viscosidade e consistência são semelhantes ao aumento de 8 vezes na concetração do acrilato Acrilates/C10-30 Alquil Acrilate. (18-21) Foi possível observar diferenças estatística entre todas as formulações com as maiores concentrações de polímeros. No entanto, nas concentrações mais baixas não foram encontradas diferenças significativas entre as formulações com diferentes polímeros. Entretanto, para a consistência, foi encontrada uma diferença significativa (p<0,05) entre os valores mínimos de HEC, AAAC, e Poliacrilamina (e) Isoparafina C13-14 (e) Laureth-7, provavelmente porque o Poliacrilamina (e) Isoparafina C13-14 (e) Laureth-7 é uma emulsão inversa. Na Figura 2 é possível observar que aumentos na concentração de Poliacrilamina (e) Isoparafina C13-14 (e) Laureth-7 não influenciaram de forma pronunciada na consistência. 

Jones, Woolfson, e Brown (1997) (22) mostraram em seu estudo que a coesão diminuiu com o aumento da concentração de polímeros como HEC. Em nosso estudo, essa propriedade teve um aumento não significativo para HEC e Poliacrilamina (e) Isoparafina C13-14 (e) Laureth-7, no entanto, para Acryloydimethyltaurate de Amônio / Copolímero VP e AAAC foi possível observar um aumento significativo (p<0,05) com o aumento da concentração de polímero. Além disso, a maior concentração de HEC foi significativamente diferente dos demais polímeros (p<0,001) nas maiores concentrações. É importante ressaltar que, no estudo citado, o HEC foi combinado com a clorexidina, o que poderia modificar esse parâmetro.
tions as the concentration of polymers increases. How-
ever, for HEC the difference between both parameters was higher in relation to the others. This may affect the sensory properties of the formulation, since cohesiveness is related to the performance of the formulation when applied, while the firmness is more correlated with the structure of the formulation. In fact, it was possible to observe the very similar behavior between work of shear and cohesiveness in the measurements (Figure 2). However, for HEC, the alterations in the concentration reflected in a higher increase in the firmness, likely because the HEC did not present lateral chains in its structure.

Higher viscosities associated to carbomers compared to other synthetic polymers were found in the literature. (23, 24) Even with this superior behavior, all the viscosities in minimal concentrations showed no significant difference between each other and low values. This characteristic is desired in cosmetic vehicles because of their high viscosity values, which implies a superior work of shear on skin, impairing the spreadability. (25, 26)

All polymers, with their structural characteristics, can help to improve sensorial proprieties; however, the knowledge about how polymers and their concentrations can influence the sensorial proprieties is important for the correct choice of these raw materials. (5) Finally, considering that there are a few studies reported to physico-mechanical properties of the formulation based on polymers, the present study is important for a better comprehension of raw materials on topical formulations. Furthermore, this study can be useful for future pharmaceutical studies on topical formulations, giving information about better concentrations of polymers to be utilized. (21, 22, 27)

Conclusions

The Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7 polymer was the modifying agent with the greatest influence on the physico-mechanical properties of the developed formulations when the concentration varied without changing the other raw materials of Calixto e Maia Campos (2017) (12) mostraram em seu estudo que a relação entre firmeza e coesão era perfeita e positiva, ou seja, se um desses parâmetros aumenta, o outro também aumenta proporcionalmente. Em nosso estudo, isso acontece com todas as formulações à medida que a concentração de polímeros aumenta. No entanto, para o HEC a diferença entre os dois parâmetros foi muito superior em relação aos demais. Isso pode provavelmente afetar as propriedades sensoriais da formulação, uma vez que a coesão está relacionada ao desempenho da formulação quando aplicada, enquanto a firmeza está mais correlacionada com a estrutura da formulação. De fato, foi possível observar o comportamento muito semelhante entre o trabalho de cisalhamento e coesão nas medições (Figura 2). No entanto, para o polímero HEC, as alterações na concentração refletiram em um aumento maior na firmeza. Provavelmente porque o HEC não apresenta cadeias laterais em sua estrutura.

Viscosidades mais altas associadas aos carbômeros em comparação com outros polímeros sintéticos foram encontradas na literatura. (23, 24) Mesmo com este comportamento superior, todas as viscosidades em concentrações mínimas não apresentaram diferença significativa e valores baixos. Essa característica é desejada em veículos cosméticos por causa de seus altos valores de viscosidade, o que implica em um trabalho superior de cisalhamento na pele, prejudicando a espalhabilidade) de. (25, 26)

Todos os polímeros, com suas características estruturais, podem ajudar a melhorar as propriedades sensoriais; entretanto, o conhecimento sobre como os polímeros e suas concentrações podem influenciar as propriedades sensoriais é importante para a escolha correta dessas matérias-primas. (5)

Por fim, considerando que existem poucos estudos relatados que avaliam as propriedades físico-mecânicas de formulações à base de polímeros, o presente estudo contribui para uma melhor compreensão do comportamento das matérias-primas adicionadas em formulações de uso tópico. Além disso, pode contribuir para futuros estudos farmacêuticos que envolvem o desenvolvimento de formulações tópicas fornecendo informações sobre melhores concentrações de polímeros a serem utilizados. (21, 22, 27)
the formulations. On the other hand, the Ammonium Acryloyldimethyltaurate/VP Copolymer did not alter the physico-mechanical properties of the formulations studied. The HEC polymer showed to be more instable with increasing concentration. For the carboxyvinilic polymer, a significant alteration in the parameters was observed when the lowest and the highest concentrations of the polymer were applied in the developed formulations.

Finally, the type of polymers, as well as its lateral chains, could result in formulations with different physico-mechanical properties, reflecting its performance when applied on the skin. Therefore, the evaluation of the physico-mechanical properties of cosmetic formulations contributes to a better understanding of the behavior of the formulations during application on the skin, which can influence in the performance and acceptance of the same.

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Conflict of Interests

None of the authors declared any conflict of interests

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Conflito de Interesses

Nenhum dos autores declarou qualquer conflito de interesses
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