

# Simulation models for hair-liquid interaction

DATA

## Background

The interaction between hair and liquids, particularly water, has been a significant focus for industries like video, animation, and gaming. Models developed in these fields simulate water behavior on hair in visually complex scenarios, capturing elements like surface tension, capillary forces, and drag effects. Leveraging principles of fluid dynamics and mechanical interactions, these simulations can realistically depict strand cohesion due to liquid bridges or the drag forces impacting submerged hair movement.

These detailed insights into fluid interaction show promising potential for adaptation within the cosmetics industry. If these physics-based frameworks could integrate molecular interaction models, they would not only simulate the physical dynamics of fluids on hair but also evaluate crucial factors for cosmetics, such as how cosmetic ingredients bond, penetrate, and wash off over time, and what impact they have on attributes like moisture level, elasticity, and surface smoothness.

This combined approach could benefit cosmetics research by capturing both immediate and long-term interactions between different hairs and different hair products, and simulating life-like scenarios—like rain exposure, humidity, washing, drying, styling, and combing—to understand how products perform under various daily conditions. Such models would enable research into diverse product functions, from adhesion and retention of styling products to the cleaning efficiency of shampoos.

## What we're looking for

We are looking to develop a simulation framework that integrates chemical and physical modeling to predict the effects of various ingredients or formulations on diverse hair types, as well as track how hair properties (e.g. hydration, elasticity, friction, cuticle alignment, porosity) change before and after product application. The goal is to capture both immediate transformations (in seconds) and progressive changes (over days or weeks). The ideal solution would combine molecular interactions with fluid dynamics to simulate complex hair-liquid interactions under realistic, varied conditions (e.g., exposure to humidity, rain, styling, blow-drying, and washing) across different hair textures and time scales. While we have a preference for visual simulations to observe product-hair interactions in dynamic scenarios, we are also open to models that provide simplified numeric data outputs for evaluating the performance of a wide range of products with unique functional goals.

**Solutions of interest include:**

- Models that simulate hair-product interactions
- Integrated molecular and physical interaction models
- Multiscale (molecular, micro, and macro) models

**Our must-have requirements are:**

- Capability to provide output data that correlates with product performance
- Applicable to any single category of cosmetic hair products (e.g., hair color, styling products, shampoos, conditioners, oils)

**Our nice-to-have's are:**

- Forecasts essential hair properties (e.g., tensile strength, porosity, cuticle alignment, moisture levels, elasticity) both prior to and after product application
- Assess the performance of products in achieving their intended benefits
- Predicts how different formulations bond with hair fibers under various conditions
- Predicts product adhesion and penetration
- Simulates wash-off behavior/ long-term retention
- Incorporates variables like humidity, temperature, UV exposure, and water presence
- Predict changes in product performance over time (supports time scale)
- Generates basic visual simulations with moderate graphics

**What's out of scope:**

- Models limited to purely physical simulations that lack integrated molecular or chemical interactions between hair and cosmetic ingredients

**Acceptable technology readiness levels (TRL): Levels 3-9**

1. Basic principles observed
2. Concept development
3. Experimental proof of concept
4. Validated in lab conditions
5. Validated in relevant environment
6. Demonstrated in relevant environment
7. Regulatory approval
8. Product in production
9. Product in market

**What we can offer you****Eligible partnership models:**

- Sponsored research
- Co-development
- Supply/purchase
- Equity investment
- Licensing

**Benefits:****Sponsored Research**

Up to \$50K for a proof-of-concept, with additional potential funding for further development of the project.

**Expertise**

Partners will have access to Henkel's domain expert knowledge within the context of the proof-of-concept.

**Data**

Necessary data for the validation of the developed model can be provided based on project requirements.

**Who we are**

Bringing numerous product innovations to the market, like the first self-acting laundry detergent in the world, the first ever liquid hair shampoo and the first hair spray, just to name a few – we have shaped the lives of millions of people. Henkel looks back on a great history of innovations that revolutionized markets multiple times, and this tradition still continues to this day through continuous investments in research and development. Together with universities and other research institutes, the international research team at Henkel Consumer Brands is constantly developing innovative products to delight our customers and consumers and exceed their expectations.

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