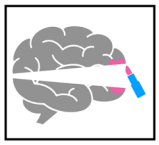

food for thought

"Food for Thought" explores the relationship between food/drink and chemical engineering processes/concepts.

PUCKER UP!

Margot Vigeant
Bucknell University • Lewisburg, PA 17837

Pop Quiz! What *isn't* food, but must be designed for consumption?

Quite a lot of products are designed this way, it turns out. The entire category of oral medications and dental hygiene products is designed with their intended or incidental consumption in mind. Any toddler's caregiver will tell you that as much non-toxic crayon ends up *in* the toddler as it does on the paper (or wall). And cosmetics are designed with the knowledge that components will be at least absorbed through the skin, and sometimes consumed more directly.

This may seem like a switch from food, but bear with me for a minute. Cosmetics have been used by people the world over for as long as we can find records.[1] Depending on your job, social class, location, and century, cosmetics might be an essential part of preparing for the stage, going to war, participating in ceremonies, and/or simply looking good.[2] Like tea,[3] cosmetics seem to be something that humans of all geographic regions and genders have had a use for at some point, making it an important bridge for reaching all of our students.

While cosmetics might seem to be a completely distinct category from food and therefore an odd fit here at *Food for Thought*, there are at least two important commonalities. First, in the United States, aspects of food and cosmetics are set by the same legislation and overseen by many of the same governing bodies.[4] The second commonality is more important and quite likely the reason for the first — while cosmetics aren't *food,* they do end up being ingested into the body — through the skin, in the eyes, and even eaten. Lipstick and related lip cosmetics such as lip balm and gloss are prime examples of non-food that absolutely, 100%, must be designed to be eaten because it invariably will be. How do we design something intended to simultaneously be not-food yet edible? Sounds like a great chemical engineering design problem!

I am a big fan of hands-on ChemE product-design projects.* Making a new lipstick/lip balm is a project that could be run as the core project of a first-year design experience, a day-long design jam for pre-college students, or as a warmup project for a design course. You could also take a sub-part of this as a one-class brainstorming session because it's an instructive blend of technical, social, cultural, and regulatory elements to come up with just the goals and constraints on a lipstick design. A note that if you're going to run this as a practical design-test-iterate project, you'll need to build the time in for your products to set up (this is part of the reason that my go-to design experience is ranch dressing — the cycle-time between design-test iterations is minutes rather than hours or days). Nevertheless, even just brainstorming about design goals and requirements can be quite instructive.

For example, we could ask a class to work together to come up with all of the features they would like to design into a lipstick or balm, all of the requirements that such a

*Science Buddies [7] has a nice example of the materials and processes you'd need to make a lip balm at www.sciencebuddies.org . Additional good ChemE-centric inspiration for our students in cosmetics can be found in the September 2023 issue of CEP Magazine.[8]

Margot Vigeant *is Rooke Professor of Chemical Engineering at Bucknell University. She teaches chemical engineering thermodynamics, applied food science and engineering, and capstone design. Margot's broad research area is effective pedagogy in engineering, including approaches to conceptual learning and inquiry-based activities for thermodynamics and heat transfer. She is also interested in "making" in engineering and using technology to broaden engagement and access. Margot completed her doctorate at the University of Virginia. She is an ASEE Fellow, Apple Distinguished Educator.*

product has to meet, and how they would assess performance on each of these metrics. While the first part is most fun — Color! Flavor! Appearance! — it's the next two steps that really bring home the engineering aspects.

Take, for example, a decision made very early on: are we making lipstick or lip balm? In the US this is quite a consequential choice because lipsticks are cosmetics while lip balms are over-the-counter drugs! [5] The impact of this decision rolls out to set forth different requirements for labeling, testing, and the claims that can be made on behalf of the product. If that's more regulation than you're looking to engage with for a short brainstorming exercise, I recommend making it a homework or bonus assignment for the students to research the regulations and see if the product they brainstormed is, or is not, subject to over-the-counter regulation — a useful exercise for any student going into the food, pharmaceutical, or the cosmetics industries.

Another challenge that's bound to come up is what phase to make your product and the attendant challenges. Lip treatments that are liquid have a number of processing advantages but require different packaging and often two hands to apply. Conventional solid lipsticks and balms have to be soft enough to spread but hard enough to not fracture under shear. This positions products in a surprisingly narrow band of properties that almost inevitably is addressed through an emulsion. There are specific material test devices and procedures used for this such as the Lipstick Bend, Flex, and Shear tester,[6] and unless you work with a Cosmetics Engineering program, these are unlikely to be available for student use. However, I find it to be instructive to have students brainstorm approaches to test for particular material properties. In the past I've been amazed that first-year students reinvent Zahn cups and rotational viscometers with fair regularity. I build on this step by letting students create and then use a low-cost "home-brew" alternative to official testing devices. For example, a shear-test of a student constructed lip balm can be found by applying a consistent force (perhaps using a scale to measure it) while swiping a balm across a piece of paper.

Long-term shelf life and product stability are other important discussion points afforded by this design problem. Emulsions are thermodynamically unstable entities and, as I like to say in class, thermodynamics always wins, *eventually*. Quite a lot of attention goes into keeping the pigments and other constituents well dispersed throughout the product within its design lifetime. It's not just phases that are a challenge for shelf life either. The reactivity of the long-chain (usually carbon-based) molecules that make up the bulk of the material is a concern as well. Pulling from food science for a moment, "rancid" is the term we apply to fats that have had some of their bonds broken through oxidation or hydrolysis as the result of environmental factors like oxygen, UV, and water exposure. You probably had a visceral reaction to the word "rancid" when you saw it, and that's because the resultant ketones, aldehydes, and fatty acids are often smelly and unpleasant, to put it mildly. A lip treatment based on long-chain carbon molecules is likely to run into the same issues as a stick of butter! But unlike butter, it's not generally acceptable to suggest that folks keep their lip products in the refrigerator, so the problem must be addressed through additives and packaging.

I would be remiss if I didn't touch on pigment as one of the engineering challenges in this space. Simply listing the requirements of the pigment is already a bit of a challenge — it must be non-toxic, possible to disperse and suspend in the base material, nonreactive, significantly flavorless and scentless…… the list goes on. If you follow this with a trip to the lab to see how easy it is to extract or synthesize something that meets the above requirements while also being *just* that correct shade, you'll develop students' appreciation for the rigor of this field.

Bringing this all together, a design project for ChemE students on lipstick or lip balm can be an exercise that not only gets their engineering minds engaged but also opens the doors wider for students who didn't realize beauty products were engineered materials. And if you take this on as a practical design challenge, everyone gets to go home with a useful result!

REFERENCES

1. Benson H, Leite-Silva V, Roberts M, and Walters K (2019) Preface. *Cosmetic Formulation: Principles and Practice*. CRC Press, Boca Raton, FL.
2. Jain NK and Chaudhri SK (2009) History of cosmetics. *Asian Journal of Pharmaceutics*. 3(3):164. https://doi.org/10.22377/ajp.v3i3.260
3. Vigeant M (2023) Food for thought: Tea time. *Chemical Engineering Education*. 57(2): 85. https://doi.org/10.18260/2-1-370.660-132886.
4. Regulations USCOF (1938) Federal Food, Drug, and Cosmetic Act (FD&C Act). https://www.fda.gov/regulatory-information/laws-enforced-fda/federal-food-drug-and-cosmetic-act-fdc-act accessed July 14, 2023.
5. Baki G (2015) *Introduction to Cosmetic Formulation and Technology*. Wiley, New York, NY.
6. Mecmesin (2019) Lipstick shear force resistance. https://www.mecmesin.com/publications/lipstick-shear-force-resistance accessed July 14, 2023.
7. De Brabandere S (2023) Cosmetic Science: Testing Lip Balm Recipes. https://www.sciencebuddies.org/science-fair-projects/project-ideas/Chem_p022/chemistry/cosmetic-science-testing-lip-balm-recipes accessed May 26, 2023.
8. (2023) Profile: Bringing plant-powered makeup to all. *CEP Magazine*. https://www.aiche.org/resources/publications/cep/2023/september/profile-bringing-plant-powered-makeup-all accessed Sept. 29, 2023.❐