Interview with Harold Freeman

Laura Dyster: Welcome to the Biocolours2024 conference podcast, where you get a glimpse of the upcoming conference next June. My name is Laura Dyster and I am part of the conference organizing team. I'm so excited to have our first keynote speaker here, Professor Harold Freeman from North Carolina State University. Welcome, Harold.

Harold Freeman: Thank you.

LD: I'm so happy that you accepted our invitation to be one of the keynote speakers of the conference and that you had time for this short interview. Harold, can you briefly share your journey as a textile dye chemist and highlight the key aspects of your 40-year career in this field?

HF: First of all, thank you very much, Laura, for the invitation to participate on a podcast pertaining to the Biocolours2024 conference. And as you framed that question, I thought, wow, it's not often that I'm asked to think back about my life 40 years ago or over the past 40 years, but I'll do my best. I'm awestruck a bit about just to think that 40 to 50 years have passed so quickly. My career journey as a dye chemist began with a transition from the pharmaceutical industry to North Carolina State University in 1982. And this followed graduate studies in organic chemistry and textile chemistry. It was then that I was invited to join the dye chemistry research program and share teaching duties as a member of the textile chemistry faculty. My career as a dye chemist has focused on the development of approaches to viable alternatives to textile colorants and the corresponding precursors that are shown to have adverse effects on human health in the environment. This work was followed by the design and synthesis of dyes that were resistant to fading during prolonged and repeated exposures to sunlight. Most recently, our dye chemistry group has focused on the use of waterless methods for applying natural dyes to textiles. This actually extends our work to a focus on engineering of dyes to protect the health of the environment as well as human health.

LD: So that's 40 years in a couple of sentences. Thank you, Harold. So you wanted to discuss under the theme of “Color yes, cancer no”. So obviously it suggests a connection between color and health. Could you provide an overview of how your work intersects with color in textiles with considerations for health, particularly in relation to cancer?

HF: Yes. I think few people realize that textile coloration has long been the number one use of commercial dyes, whether they are natural dyes or synthetic dyes. And many of these dyes, that is the synthetic dyes, have been azo compounds. This is important because certain azo dyes are derived from raw materials that have the potential to cause cancer in humans, as well as laboratory animals. Thus, such dyes have been banned from the marketplace, and alternative colorants have been pursued with considerable success, I might add. This work, our work in this area, took advantage of my background in the development of organic compounds in the pharmaceutical industry that were intended to have targeted effects on human health, things like improving blood pressure or treating Parkinson's disease. So my pre-textile background was important in that it allowed us to develop new compounds that have biological activity. And in the case of dyes, we don't want to have biological activity that is adverse to human health and the environment.

LD: This is something that a normal consumer doesn't necessarily think about when buying clothes, that what's the chemistry behind the bright color and what effect it could have on your health and also on the environment. So how do you approach the balance between achieving vibrant colors in textiles and ensuring that the materials used are safe from a health perspective?

HF: Interestingly, I think much is known about the structural features required for dyes to have affinity for textiles and also to have a specific color for textiles. We also know quite a bit about structural features associated with dyes that pose risk to human health, dyes that are hydrophobic are easily taken up into the tissues of body and move to the liver and undergo metabolism to produce substances that are more hazardous than the original or the intact dyes themselves. For example, textile dyes having the potential to undergo metabolism to any of a group of aromatic amines, about two dozen aromatic amines, are known to be cancer suspect agents and must be avoided. With this in mind, the target features can be built into the structures of dyes that give both specific color and affinity for the fiber, as well as providing safety in terms of human health risks.

LD: You mentioned earlier waterless dyeing technologies, and you've explored these like SCCO2, is that the way to say?

HF: Supercritical CO2.

LD: Okay, supercritical. Okay, thank you. And atmospheric plasma treatments. How do these technologies align with the theme of “Color yes, cancer no”? And what benefits do they bring to textile dyeing?

HF: Right, and it was really the opportunity to extend our work pertaining to safety regarding human health exposures to dyes and the environment. I think the initial 20 years of our work focused on designing dyes that had the potential to undergo metabolism in the body to produce breakdown products that we wanted to be safe and not posing a risk to human health. So most of the human health side of our work was the focus of the design and synthesis status. And with CO_2 and atmospheric plasma, we were able to address the environment side. I think few people also would appreciate just how much water is generated in the dyeing of a single t-shirt. I mean, at least 30 or 40 gallons for one t-shirt. That's a lot of water and it may be converted to or end up as wastewater that enters the environment following some type of wastewater treatment. And so we regarded it as important to develop technologies that don't require water. And that's the beauty of supercritical carbon dioxide. It's really the liquid form of CO_2 that's used as a dyeing medium for textiles. So when that dyeing medium is withdrawn, you actually have a dry fabric. That means you don't need a drying step, a drying process, it saves energy, as well as circumventing the production of wastewater that has to be treated in some way. That's also true of atmospheric plasma technology. It involves the dyeing of textiles without having to use water.

LD: Are these technologies in use on a larger scale?

HF: Not for textiles. Not for textile dyeing, I should say. Finishing of textiles to give water repellency is probably the main use of atmospheric plasma technology. And supercritical CO_2 is now coming into its own for textiles dyeing. Primarily because of the significantly higher cost associated with CO_2 dyeing versus dyeing in water.

LD: So using these technologies on a larger scale in dyeing fabrics is still in the future.

HF: Yes, I think on a large scale. There are some companies that do some dyeings using CO_2, but not many.

LD: Thank you. So we're talking about biocolorants, obviously, in the conference. So how do you see the integration of biocolorants impacting the future of textile industry, especially in terms of color choices and consumer health awareness?

HF: Right. And I think at present, the interface involves the environmental benefits, and that's because natural dyes are biodegradable, they are renewable, they are non-petroleum-based colorants, and especially one would which to emphasize, I think, the biodegradable aspects and the renewable aspect of natural dyes giving some benefit over synthetic dyes.

LD: So my second to last question is, what message would you like to convey to the audience about the significance of your work in the context of “Color yes, cancer no”?

HF: I think probably the main message would involve the fact that guidelines are now in place for the selection of dyes having affinity for textiles while posing little to no risk to human health. And in this regard, more information regarding synthetic dyes is available compared to natural dyes. And our works seeks to help fill the key void in this area.

LD: And my final question, Harold, is when you close your eyes, what color do you see when you think about the Biocolours2024 conference?

HF: Probably red. It's one of my favorite colors. And also, it has been the most challenging color to produce to ensure that we have stability, photo stability in dyes. Some of them tend to fade and there's a challenge to generate alternatives. So that's one point. The second point is that most of the natural dyes that we've worked with produce either red or yellow. The dyes themselves are red and the color on textiles is more of a yellowish orange. And so the red color from the types of natural dyes that we've been using and the red color from the work we've been doing to enhance the photo stability of dyes that are used for automobile interiors. So that's why I say red.

LD: Okay. Thank you so much for this interview, Harold. I really look forward to seeing you at the conference next June.

HF: Yeah. And hopefully, I had something to share that was not too jumbled.

LD: I'm sure this is a very informative interview for the greater audience. Thank you, Harold.

HF: My pleasure.