The self-image that we project to others is a profound statement of who we want others to believe we are, particularly now, when so many meetings and gatherings are virtual. In recent history, people have become bolder in their self-image choices. The hair, for example, is a fantastic medium to make a statement of one’s narrative. The color of one’s hair can speak volumes. The current global hair dye and color industry’s market value is around 30 billion US dollars and projected to be about 42 billion US dollars by 2025. However, this market lacks diversity in its natural options of deep, dark pigments and dyes. There is also a deep concern over the toxicity of many hair-dyeing agents. The challenge to develop more nontoxic, mild, and biocompatible pathways for dyeing hair is ongoing. While henna is a natural plant-based pigment that has been used in many cultures for dyeing hair and creating body art, it is limited to the red color spectrum. Battistella et al. more recently reported a novel, bioinspired, and nontoxic approach to hair pigmentation.

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Hair is an important aspect of physical appearance; nature creates varying shades of human hair ranging from the palest blond to brown, red, and to deepest black. Quality, quantity, and distribution of two types of melanin pigments in hair determine color: eumelanin is responsible for brownish black coloration, whereas pheomelanin is responsible for reddish-yellow coloration. The absence of these pigments leads to white or gray hair. In order to maintain hair color, an increasing number of people dye their hair, resulting in an increase in the demand for permanent hair dye. However, the majority of permanent dye products are accompanied by toxic reagents and carcinogens such as chelators that remove metals and minerals from hair that has been exposed to hard or/chlorinated water as well as strong oxidants that bleach hair to enhance its ability to accept hair dye. Unlike the aforementioned, Battistella and co-workers have developed unique nontoxic dyeing agent. Their research focused on using nature-inspired materials. During the past few years, considerable attention has been focused on using melanin-inspired pigments called polydopamine (PDA) as a hair coloring agent; however, most of the reported protocols require toxic heavy metals and harsh conditions, which may hinder accessibility.

In this issue of ACS Central Science, Battistella and co-workers demonstrate an efficient darkening of human hair via a milder process not involving metal chelators or strong oxidants. For this hair dyeing protocol, the authors first produced the melanin-inspired pigment, polydopamine (PDA), from dopamine using natural air in an aqueous ammonium solution (Figure 1a).

Utilizing this PDA deposition process, uniform darkening of gray hair can be achieved around physiological temperatures (37–40 °C) within 2 h (Figure 1b). Moreover, different shades of hair color could be achieved by controlling the reaction temperature and ammonium hydroxide concentration (Figure 1c). Warmer and orange/gold natural shades were introduced with dilute H₂O₂ (<3%, 1 M).
Although hair pigmentation by conventional permanent hair dyes leads to long-term coloration, the penetration of small molecule dyes into the cortex and application of harsh conditions make these methods invasive. Thus, it would be important to understand the PDA deposition mechanism of this novel protocol. Studies that examine the hair cortex (the layer of the hair shaft that contains most of the hair’s pigment) showed that PDA deposition occurred as nanoparticles on the surface of the hair shaft without deep penetration into the hair cortex. Further, this colored layer was resistant to greater than 10 washes with shampoo and did not alter the mechanical properties of hair. To determine the versatility of this methodology, authors performed reactions using various colored, straight hair samples such as natural red, brown, gray, and previously dyed hair and proved that PDA deposition via this protocol was compatible with a wide range of hair colors (Figure 1d).

More work remains to be done to ensure that this new hair dye protocol has maximal utility, such as testing across a diversity of hair textures.

chemical reactivity, and biocompatibility. Therefore, this strategy is applicable not only to hair coloration and the cosmetic industry but also to other areas such as biomedical applications (biomimetic sensing, bioimaging, cancer therapy), energy storage, and military sectors.

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