New technologies are enhancing color consistency in ceramic tile via algorithmic color formulation. Image Source: Flickr user Living Rooms London

Ceramic tiles are one of the most versatile and widely used **building materials** in existence. Both practical and decorative, these tiles can be incorporated in a multitude of ways within both residential and commercial structures, where they adorn everything from walls to floors to ceilings. With the surging interest in home decorating and renovation, consumers are more willing to experiment with unique shapes and colors than ever before.

But as interest has grown, so too have aesthetic standards, as consumers expect both a wide variety of color and color consistency in ceramic tile production. UV spectrophotometric analysis of emerging color formulation technologies is playing an essential role in expanding and enhancing the variety and quality of color, helping researchers create new and improved methods of controlling the look of these functional and often beautiful products.

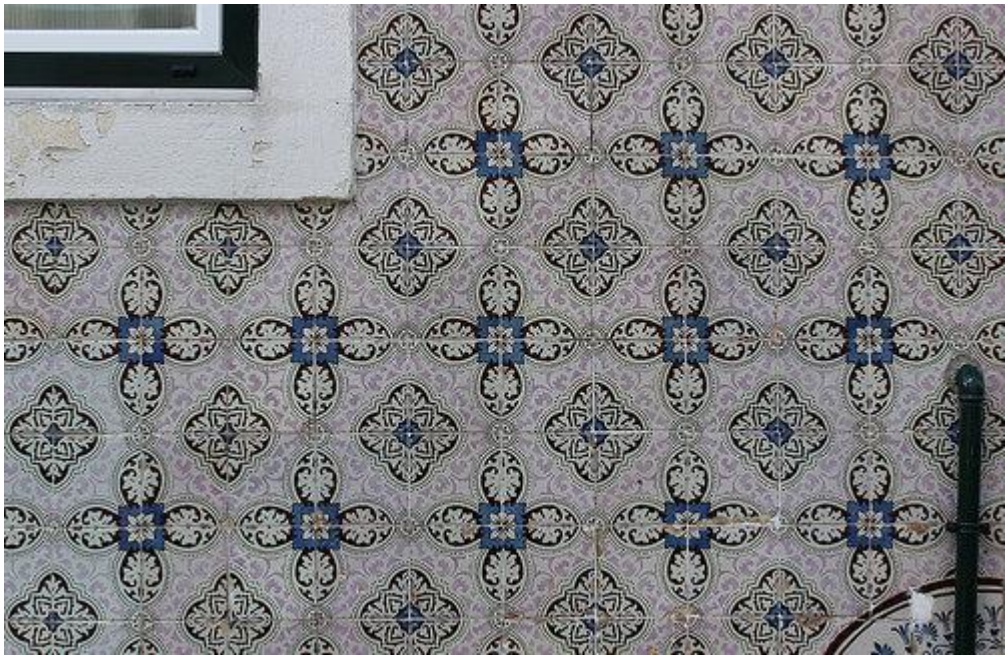
While color formulation algorithms have become standard in many industries, ceramic tile production presents special challenges for implementation of this unique technology.
Image Source: Flickr user DuPont Surfaces

The Benefits and Limits of Algorithmic Color Formulation

In an effort to increase the efficacy of production, accuracy of coloration, and precision of color matching, many industries—including paper, plastics, and textiles—have turned to algorithmic color formulation. These algorithms expand color selection using a minimal number of pigments, enhance color matching abilities, and reduce waste by allowing manufacturers to prepare only the exact quantity of mixtures required. Until recently, however, color formulation algorithms have largely failed to translate to the ceramic tile industry, due to the unique characteristics of ceramic material itself:

The most important is connected with thermal and chemical stability that pigments must have towards the molten glass developed during the firing cycle at high temperature: the same pigment, in fact, can develop slightly different colors depending on both firing temperature and chemical composition of glaze and ceramic body to color.[1]

Color variation in the tile body, grain size distribution, firing process variations, and interactions between pigments and glazes all contribute to the unpredictability of color development.[2] Unfortunately, the very same attributes that present challenges to algorithmic color formulation are the very reasons such methods would be so advantageous to the ceramic tile industry; incorporating algorithmic technology would diminish unwanted batch to batch and lot to lot color variations, producing more stable coloration to satisfy consumer demand.



Refinement and application of new color formulation algorithms could not only improve color consistency and quality in mass ceramic tile production, but facilitate historic restoration and small-batch reproduction.
Image Source: Flickr user Metro Centric

Spectrophotometric Evaluation of Color Consistency in Ceramic Tile

In 2006, however, a group of researchers developed an effective color matching algorithm for ceramic tile using the Kubelka-Munk theory verified via **UV spectrophotometric evaluation**. In a study published in the *Journal of the European Ceramic Society*, the researchers developed a system of four industrial pigments that served as the basis for formulation. By applying the principles of the Kubelka-Munk theory, they were able to create an efficient algorithm for the formulation of ceramic tile pigments. Five target colors were analyzed using a UV spectrophotometer and their reflectance spectra compared to the Natural Color System standards to determine color accuracy.

These spectrophotometric measurements not only allowed the team to determine the efficacy of the algorithm, but also correlate color to process variables. “The decisive steps have been the introduction of a base glass in the formulations and the characterization of the colored glazes after firing,” they note. Furthermore, the method revealed predictable color differences based on firing temperature variation, suggesting that carefully modulated temperature controls could significantly enhance color consistency.

Further development and widespread implementation of such color formulation algorithms could increase quality, variety, and consistency in mass ceramic tile production while helping tile manufacturers increase efficiency and realize cost savings. At the same time, it could also facilitate partial tile replacements as well as historical preservation, restoration, and reproduction by allowing for precise color matching and economically viable small-batch or even one-off production.[3] UV spectrophotometry will continue to play an integral role in the development and evaluation of any new algorithmic technologies, owing to its high degree of accuracy, **versatile optical geometries**, and **precise, objective quantification of color information**.

HunterLab Color Measurement

HunterLab has been a pioneer in the field of color measurement for over 60 years. During that time, our instruments have helped researchers and manufacturers develop and deploy new technologies that enhance color formulation and production processes across industries. Today, we offer a complete range of portable, benchtop, and in-line spectrophotometers engineered to give you unprecedented insight into color behavior and expanding your ability to collect, analyze, and share color information. **Contact us** to learn more about our line up of color measurement instruments, customizable software packages, and world-class customer support services.

1. "Color Matching Algorithms in Ceramic Tile Production," January 19, 2005, https://www.researchgate.net/publication/228108792_Color_matching_algorithms_in_ceramic_tile_production

2. "Ceramic Tile," http://www.madehow.com/Volume-1/Ceramic-Tile.html

3. "Preserving Historic Ceramic Tile Floors," October 1996, https://www.nps.gov/tps/how-to-preserve/briefs/40-ceramic-tile-floors.htm