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Chemistry, Chemical Engineering, Versace and Monet

Abstract

Chemical engineering and aesthetics are rarely included in the same sentence. The predisposition to choose function over aesthetics has led artists and designers to be among the first to mock an engineer's sense of fashion or decorating know-how. However, setting these stereotypes aside, chemical engineers have been indispensable in the advancement of the fashion industry and possibly entire artistic movements. Chemists and chemical engineers have made colors less toxic, more humane to produce, and much more affordable. Technical developments brought color to many people whose lives were rather gray prior to synthetic and large-scale production of pigments and dyes. Synthetic dyes and pigments have made vibrant colors cheaper and more readily available in large quantities. This has opened up the world of colors to the average person in terms of fashion and household decorating. It has also allowed artists to use colors more liberally, changing painting styles and contributing to artistic movements such as impressionism.

Introduction

Mauve (Figure 1), first synthesized by William Perkin in London in 1856, was originally named Tyrian Purple to increase its value. Prior to Perkin, Tyrian Purple was prohibitively expensive; thousands of mollusks (shellfish) from the Mediterranean were required to dye a single robe purple.

Production of Mauve

Perkin's mentor, August Hofmann, was not impressed by the new color as it was not the desired synthetic quinine substitute to battle malaria. However, as an amateur artist, Perkin immediately recognized its value because synthetic mauve did not fade or lighten upon washing or exposure to sunlight.[1]

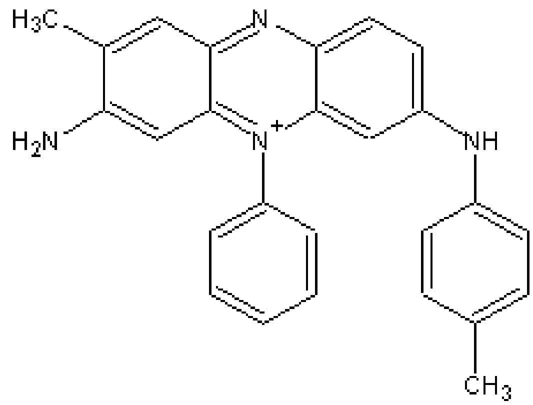

Figure 1: Chemical Structure of Mauve. 3-amino-2,±9-dimethyl-5-phenyl-7-(p-tolylamino)phenazinium acetate (acetate not pictured).

Perkin manufactured mauve from aniline using a batch process in which each cycle lasted two days. To use aniline on such a large scale was problematic, as it was not available commercially. Perkin resolved to produce aniline from coal-tar in 40-gallon vats. This proved to be economical since coal-tar was widely available as a waste product from coal-gas production. Aniline, sulphuric acid and potassium bichromate were combined in an aqueous solution and filtered to leave a fine black powder. Naphtha and other organic contaminants were removed with a highly specialized separation process. The solvent was distilled off and the remaining liquid was

[1] Garfield, Simon. Mauve, How One Man Invented a Color that Changed the World. W.W. Norton and Company, Inc., New York. (2001).

filtered, washed with caustic soda and water, and then filtered again. This left mauve in a paste-like form, with an overall yield of 0.25 oz of mauve from 100 pounds of coal. While this batch process does not appear to have a high yield or low cost, it was nevertheless much more economical compared to the Tyrian Purple produced from mollusks .[2]

Influence on Fashion in Clothing
Perkin's discovery took purple out of the exclusive world of royalty and wealth and brought it to the commoner.

The synthesis of mauve started a revolution in synthetic dye-making. Other purples, reds, blues and yellows were produced in the 10 years following Perkin's discovery. The effect on the economy was immediate. With competition from synthetic alternatives, the prices of previously expensive natural dyes such as indigo and cochineal dropped by 50 per cent.[3]

Perkin's work provides the first example of a synthetic *purple* dye. Purple is a truly pivotal color because (along with blues, until the 18th century), it had been reserved for the extremely wealthy. The availability of an affordable purple helped break down socio-economic barriers in 19th century Europe. Near the end of the 19th century, a commoner was able to have the same clothing as that of nobility, making it harder to classify a person based on outwardly visible signs alone. Perkin's work helped increase socio-economic mobility.

[2] Garfield, S, 2001.
[3] *Ibid.*

Influence on the Art World
Prior to the availability of synthetic pigments, extremely expensive pigments such as lapis lazuli and carmine (extracted from a South American insect), could only be used sparingly for portraits of wealthy patrons. The expensive pigments were usually only applied as thin glazes over existing paint.[4] The expensive blues and reds were usually reserved for painting the Virgin Mary and Baby Jesus during the Medieval period and the Renaissance.[5]

In the 17th century, when pigments were prohibitively expensive for use in paintings of commoners, Johannes Vermeer made ample use of Indian Yellow, lapis lazuli and carmine in painting servants and peasants. This audacious use of such an expensive pigment inspired the novel The Girl With a Pearl Earring by Tracy Chevalier, in which Vermeer must convince a servant girl not to tell his wife that he used lapis lazuli to paint her portrait.[6]

During the late 18th century, several synthetic methods were developed for producing blue, orange, and red pigments. Indian yellow was originally produced by concentrating the urine of cows fed only mango leaves. Indian yellow was thus costly to produce, only available in small quantities, and left cows horribly malnourished. This practice was cast aside as inhumane

[4] Pastoureau, Michel. Blue: The History of a Color. Princeton University Press, Princeton. (2001).
[5] Kassinger, Ruth. Dyes: From Sea Snails to Synthetics. The Millbrook Press, Inc., Brookfield. (2003).
[6] Chevalier, Tracy. The Girl With a Pearl Earring. Penguin Putnam, Inc., New York. (1999).

when a synthetic substitute was found. French Ultramarine (Figure 2) was a synthetic replacement for the extremely expensive pigment lapis lazuli. A synthetic pigment replaced the highly toxic vermillion (deep red-orange), which contained mercury.[7]

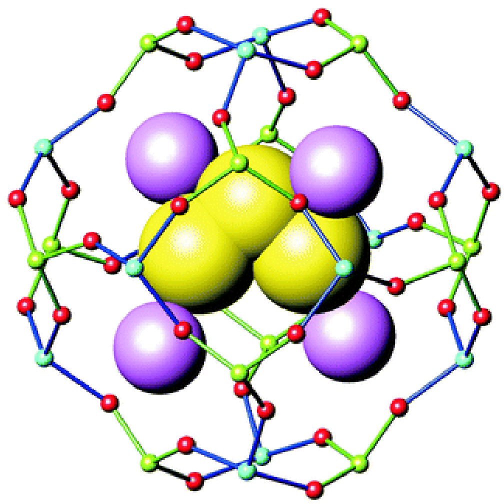

Figure 2: Chemical Structure of French Ultramarine. $Na_8[SiAlO_3]_{12}S_3$. Sulfur, yellow. Sodium, purple. Oxygen, red. Aluminum, green. Silicon, blue.[8]

The impressionist movement, starting in the 1860s and flourishing through the end of the 19th century, followed the discovery of synthetic pigments that replaced extremely expensive natural pigments. The impressionist movement, headed by Monet, Renoir and Cezanne, featured loose, visible brush strokes and mundane subjects because it was no longer necessary to reserve the reds and blues for the most important subjects. Furthermore, most impressionist painters were able to use the brush and canvas as the medium for mixing pigments. Thin glazes of expensive colors were generally not applied (as they were in the Renaissance) to create an illusion of depth. Instead, opaque paint was applied to the canvas and then mixed to produce more subtle edges and vibrant features.[9]

Conclusion

The chemist's and chemical engineer's roles in creating synthetic dyes and pigments provide one example of how cheaper, safer and more humane synthetic alternatives can affect aspects of our daily lives that appear to be unrelated to traditional chemistry and chemical engineering. Applied chemistry, aside from making items cheaper, more pure or available on a larger scale, has played a significant role in shaping the world as we know it today.

[7] Kassinger, R, 2003.

[8] Weller, Mark. Where zeolites and oxides merge: semi-condensed tetrahedral frameworks. *Journal of the Chemical Society, Dalton Transactions*, 2000.

[9] Rewald, John. The History of Impressionism. The Museum of Modern Art, New York. (1961).