Dyes and Colorants from Algae

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Introduction

Dyes and Colorants from natural sources are gaining importance mainly due to health and environmental issues. Algae contain a wide range of photosynthetic pigments. Three major classes of photosynthetic pigments are chlorophylls, carotenoids (carotenes and xanthophylls) and phycobilins. Phycocyanin and phycoerythrin belong to the major class of phycobilins photosynthetic pigment while fucoxanthin and peridinin belong to carotenoid group of photosynthetic pigment. The table below elucidates the different types of algae and the major pigment they contain.

Division	**Common Name**	**Major Accessory Pigment**
Chlorophyta	Green algae	chlorophyll b
Euglenophyta	Euglenoids	chlorophyll b
Phaeophyta	Brown algae	Chlorophyll c1 + c2, fucoxanthin
Chrysophyta	Yellow-brown or golden-brown algae	chlorophyll c1 + c2, fucoxanthin
Pyrrhophyta	Dinoflagellates	chlorophyll c2, peridinin
Cryptophyta	Cryptomonads	chlorophyll c2, phycobilins
Rhodophyta	Red algae	phycoerythrin, phycocyanin
Cyanophyta	Blue-green algae	phycocyanin, phycoerythrin

Source: http://www.clarku.edu/faculty/robertson/Laboratory%20Methods/Pigments.html

The advantages of using algae as the source of dyes and food colorants are

1. *Nutritional Value*: Most of the pigments have high nutritional value unlike their synthetic counterparts.
2. *Eco-friendliness*: The process of production of natural dyes from algae does not involve the usage of harmful and/or polluting chemicals. The majority of these effluents are biodegradable and can also be reused as fodder, bioplastics etc.
3. *Non-Toxicity and Non-Carcinogenicity*: Pigments derived from algae have been certified as safe for usage as food colorants.

These reasons have contributed to the increase in the need for non-toxic eco-friendly colorants and dyes from Algae.

Common Algal Pigments

The following pigments are industrially important products.

1.) Phycoerythrin

- Phycoerythrin is a red pigment extracted from red algae (Rhodophyta).
- ***Porphyridium cruentum*** is the most commonly used species for phycoerythrin production.
- It is cultured in artificial seawater with added Potassium Nitrate.
- Optimum temperature of growth for Porphyridium is 21°C.

2.) Phycocyanin

- Phycocyanin is a blue pigment derived from blue green algae (**Cyanophyta).**
- ***Spirulina platensis*** is the most popular algal source of this pigment.
- It requires an alkaline pH range of 7.2 to 9.0 and a salinity of 30 g/l.
- In the wild, Spirulina grows at 27°C.

3.) Beta-Carotene

- ***Dunaliella salina*** a halophilic green algae is used for beta-carotene production.

- This pigment is used mainly as food colorant and it imparts a Yellow-Orange color.

- Apart from its use as a colorant, it is used popularly as a nutraceutical additive because it is rich in Vitamin A.

4.) Chlorophyll

- This photosynthetic green pigment is mainly derived from ***Chlorella sp.***

- Chlorophyll as a food colorant is found to exhibit anti-mutagenic property.

- This is accomplished by inducing production of Carcinogen Detoxifying Enzymes, and thereby reducing the risk of Cancer.

5.) Fucoxanthin

- This pigment derived from ***Phaeophytes*** is used for coloring food products brown.

- It is well researched upon for its fat reducing properties.

Role of Diatoms as Algal Pigments

- Diatoms are a group of algae which have a unique cell wall made of Silica, known as frustule.

- The hard silica shells exhibit iridescence and they behave like crystals. The configuration of holes in these shells affects the color exhibited and this phenomenon has found application in dyeing fabrics without chemically altering their composition.

- Diatoms have also found to be efficient additives to Dye Sensitized Solar Cells. Their nanometer pores trap light that enters the solar cell. This increases interaction and improves efficiency of capture of solar energy. Diatoms sensitized Solar cells have the advantage of easy fabrication at room temperature.

Source:http://www.wired.com/science/planetearth/news/2007/10/eco_textiles#ixzz0nbdyt2lv

Extraction of Algal Pigments

- Chlorophylls and carotenes are generally fat soluble molecules and can be extracted from thylakoid membranes with organic solvents such as acetone, methanol or DMSO.

- The phycobilins and peridinin, in contrast, are water soluble and can be extracted from algal tissues after the organic solvent extraction of chlorophyll in those tissues.

- Industrial extraction of these pigments involves homogenization (disintegration) of algal biomass, followed by solvent treatment using an organic solvent mixture (Chloroform-Hexane-Ether-Methanol).

- The pigment can be extracted from the supernatant of the mixture after solvent treatment by various methods including chromatographic methods.

Applications

- **In Food Coloring:** Phycocyanin colorants in general are non-toxic and non-carcinogenic. Uses of phycocyanin in foods include the coloring of fermented milk products, ice creams, chewing gum, soft drinks, alcoholic drinks, desserts, sweet cake decoration, and milk shakes.

- **In Clothing:** Chlorophyll Derivatives are used for dyeing of fabrics such as wool, acetate derivatives and cotton.

- **In Pharmaceuticals:**

    - ✓ Beta-carotene used in food coloring is a source of Vitamin A.The human body converts beta-carotene to vitamin A via body tissues as opposed to the liver, hence avoiding a build up of toxins in the liver.
    - ✓ Beta-Carotene has antioxidant qualities.

- **In cosmetics:** Algal pigments are used for adding exotic colors to soaps. Sea weeds (Macroalgae) are a source of pigments for various hair coloring products due to their long lasting properties.

- **In Paint Additives:** Diatoms are also used in paint additives, other than algal pigments, due to the iridescent nature of their silica shells.

- **In Paper Industry:** The paper products used generally are not recyclable because of the chemical inks they use. The paper industry is shifting their focus to algae because the inks derived from them are easy to break down and hence easily recyclable.

- **In Cancer Research**: Both phycocyanin and phycoerythrin fluoresce at a particular wavelength. The light produced by this fluorescence is so distinctive and reliable, that phycobilins may be used as chemical "tags". The pigments are chemically bonded to antibodies, which are then put into a solution of cells.

Conclusion

Due to increased interest in bio-fuels and food supplements of algal origin, in the recent times, there is widening scope for industries to exploit the availability of other algal products, mainly dyes, fodder and bio-plastics. Though algal pigments have the drawback of being unstable at high temperature, an effective solution involves using thermophilic algal pigments. Investing in these fields would both increase profitability and reduce wastage of resources (in the form of expelled biomass) for those involved in alga culture.