PROSPECTIVE ASPECTS OF MYCO-CHROME AS PROMISING FUTURE TEXTILES

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ABSTRACT

Natural dyes occupy significant position in various industries like food, pharmaceutical, and paper, etc. Natural dyes from plants and microbes are emerging as a new trend in current tech-savvy world due to the increasing awareness among the upcoming generation about synthetic colorants and its harmful effects. Apart from plants, natural dyes, pigments or colorants can also be extracted from insects, algae, bacteria, fungi and yeasts. Natural colorants are extracted using water or solvents, characterised and formulated as textile dyes, pigments or colorants. Application of microbial dyes, pigments or colorants for textile industry poses various challenges due to their low stability with varying pH and temperature; hence it demands for an intense investigation on microbial dyes so as to establish an eco-friendly textile in India and to extrude a novel dye for textile dyeing.

Keywords: fungi, mushrooms, dyes and pigments, textiles dyeing, industrial application

INTRODUCTI ON

Art and colour has been important since the very beginning of human existence. The natural pigment was the colour of the first art in cave paintings. The four basic pigments of our early heritage were yellow, red ochre, black and white [1]. Nature-identical colors are man-made pigments which are also found in nature. Examples are carotene, canthaxanthin and riboflavin. Synthetic colors are man-made colors which are not found in nature, these are often azo-dyes. Examples of inorganic colors are titanium dioxide, gold and silver. Although structurally very diversified and from a variety of sources, natural colorants can be grouped into a few classes, the three most important of which are: tetrapyrrols, tetraterpenoids and flavonoids. The terms “pigment” and “dye” are often used interchangeably. Strictly speaking, a pigment is insoluble in the given medium, whereas a dye is soluble. Thus, carotenoids are dyes in oil but pigments in water. This distinction may be difficult to maintain if nothing is assumed about the medium and in the following the term “pigment” will be used for colored substances in general [2].

Natural dyes, dye stuff and dyeing are as old as textiles themselves. Man has always been interested in colours; the art of dyeing has a long past and many of the dyes go back into prehistory. It was practised during the Bronze Age in Europe. The earliest written record of the use of natural dyes was found in China dated 2600 BC. Dyeing was known as early as in the Indus Valley period (2500 BC); this knowledge has been substantiated by findings of coloured garments of cloth and traces of madder dye in the ruins of the Indus Valley Civilization at Mohenjodaro and Harappa (3500 BC).

Synthetic dyes and environmental pollution

After the accidental synthesis of mauveine by Perkin in Germany in 1856 and its subsequent commercialization, coal-tar dyes began to compete with natural dyes. Synthetic colours were found technically more suitable than natural colours and became popular because for their fastness, available in a wide range of colours, low cost even at high concentration in low volumes [3]. The advent of synthetic dyes caused rapid decline in the use of natural dyes, which were completely replaced by the former within a century [4].

The Textile World News proclaims about the textile wastes, “Textile ranks sixth in toxic wastes” [5]. During the textile dyeing process up to 40% of dyes may remain unfixed to the fiber and contaminates the industrial wastewater. They are very stable and difficult to degrade. These dyes are resistant to microbial attack and are hardly removed from effluents by conventional biological, physical or chemical treatments [6-7]. World effluent release ranges between 5,000 and 20,000 tons per year and causes a serious pollution as well as a non - negligible risk of toxicity against living organisms. Indeed, a survey of oral acute toxicity of 4,461 dyes, evaluated by the lethal dose for 50% of treated rats, has revealed that azo and cationic dyes are the most toxic and carcinogenic to human [8-10].

Classification of natural dyes

The natural dyes are classified based on their chemical structure, sources, method of application, colour, etc. They are classified into the following groups based on chemical structure like Indigoids, Anthraquinones, Alpha- naphthoquinones, Flavones, Dihydropyrans, Anthocyanidins and Carotenoids [11].

WHY WE NEED RESEARCH ON NATURAL DYES?

Pigments from natural sources have been obtained since long time ago, and their interest has increased due to the toxicity problems caused by those of synthetic origin. In this way the pigments from microbial sources are a good alternative.

NATURAL DYES FROM MICROBES

Many microorganisms, including algae, fungi and bacteria, also produce pigments. These pigments play a protective role, for example to absorb UV radiation or to quench oxygen free radicals. Other pigments have been suggested to have antibiotic properties. Several aerobic, gram-positive, pigmented, subsurface isolates exhibited greater resistance to UV light than the non pigmented strains [12]**.** Indigo is considered to be the oldest dye [13]. It was generally extracted from various species of plants initially. However, by the end of nineteenth century the commercial synthetic indigo almost completely replaced indigo production from the natural source. More recently, research work has been undertaken to find a way to replace the chemical synthesis of indigo by using bacterial systems [14].

Dyes and pigments from Bacteria

Bacteria are a good source of pigments which are mostly carotenoids, especially β-carotene in nature. *Streptomyces chrestomyceticus* subsp. *rubescens* has been employed to producce lycopene while zeaxanthin and lutein production from *Flavobacterium* sp. is gaining importance. Several studies have been reported from bacterial pigments.

Dyes and pigments from Fungi

Many species of fungi have attracted special attention because they have the capability of producing different coloured pigments showing high chemical stability [15]. Yellow pigments epurpurins (A – C) were isolated from *Emercicella purpurea* and azophilone derivatives, falconensins (A – H) and falconοnsones (A1 and B2) were produced both by *E. falconensis* and *E. fruticulosa* [16].

Red and / or yellow pigments are efficiently produced by several strains of *Monascus* species which are commercially important [17-19]. Angkak or red fermented rice is produced from the fermentation of rice substrates by *Monascus* sp. is ground and used as a colorant. Pigments, produced from immobilized cultures of *Monascus*, are a mixture of six major related pigments (red, yellow and purple pigmented polyketides) and insoluble in acid. Anthraquinone pigments like catenarin, chrysophanol, cynodontin, helminthosporin, tritisporin and crythroglaucin are produced by microfungi *Eurotium* spp., *Fusarium* spp., *Curvularia lunata*, *Drechlera* spp., *Trichoderma* and *Aspergillus* strains [20].

Various workers have reported pigments from fungal isolates such as *Acrostalagmus* sp., *Alternaria alternata*, *Alternaria* sp., *Aspergillus niger*, *Bisporomyces* sp., *Cunninghamella*, *Penicillium chrysogenum*, *Penicillium italicum*, *Penicillium oxalicum*, *Penicillium regulosum*, *Phymatotrichum* sp [21].

Dyes and pigments from Mushrooms

A mushroom is the fleshy, spore-bearing fruiting body of a fungus and can be used for extraction of dyes and used for colouring purpose. The shingled hedgehog mushroom (*Sarcodon imbricatus*) and related species contain blue-green

Table 1: Mushrooms and colour shades obtained

Mushrooms	Color shades
Chanterelles	Mute Yellow
Oyster	Gray
Agaricus	Yellow-tan to gray green
Blewit	Grass Green
Maitake	Soft Yellow
Chicken of the Woods	Orange
Phaeolus	Orange, Yellow, Green, Red
Lepiota americana	pink to lavender

Dyeing and Paper-Making with Mushrooms Tradd Cotter Mushroom Mountain, LLC

pigments, which are used for dyeing wool in Norway [22]. The fruiting body of *Hydnellum peckii* can be used to produce a beige color when no mordant is used, and shades of blue or green depending on the mordant added [23]. *Phaeolus schweinitzii* (Dyer's Polypore) produces green, yellow, gold, or brown colors, depending on the material dyed and the mordant used (Book-Dyeing with Mushrooms) (Table 1). Extraction of anthroquinone dyes from a Polyporaceae member *Dermocybe sanguineus* showed potential dyeing properties on different fabric materials [24].

Laetiporus sulphureus (Bull.: Fr.) Murr. (Polyporales, Fungi) is a wood rotting basidiomycete growing on several tree species and producing shelf-shaped fruit bodies of pink-orange color, except for the fleshy margin, which is bright yellow. *Laetiporus* species contain a number of lanostane triterpenoids and other metabolites. Thus makes a great industrial application in food, textiles industry [25].

OUR EXPERIENCE WITH MYCOCHROME

Macro fungi (Mushroom) dyes (Myco-chrome) for future textiles

The work was initiated with isolation, followed by production of dyes from mycelial culture, simple and cost effective cultivation with successful fruiting body production, and extraction of dyes. It was followed by application of the mushroom dyes with cotton and silk yarns and fabrics. Pilot scale cultivation was successfully carried out and dyeing experiments were carried out at an industry for testing its suitability as natural dye.

An orange pigment from the fungi *Ganoderma applanatum*, *Coriolus versicolor* and *Amanita muscaria* was extracted from the basidiocarp and applied on the silk and cotton fabrics. The fungal pigment with different mordant like alum, copper, chromium, iron and tin developed color variation from orange to yellow and deep green shades in cotton and silk fabrics. Further, the dyed cotton and silk fabrics did not change the color in soap washing and sunlight drying [26]. The cost effective method of cultivation of *Ganoderma lucidum* and application of its dyes to cotton and silk yarns were done and the dyed yarns showed good fastness tests [27]. Cost effective method of cultivation of *Pycnoporus sanguineus* and application of its dyes to cotton and silk yarns and fabrics were done and the tested up to industrial level [28]. Based on the positive outputs from the above research, production was scaled up and industrial level of testing was carried out. Industrial dyeing was carried out at the site of the industry and natural dyeing trial was attempted in meters and the cotton fabric premordanted with various treatments and dyed with various mushroom dyes recorded fair to good wash fastness [29-30].

Microfungi dyes (Myco-chrome) for future textiles

Pigment from *Sclerotinia* sp. (pink) was exploited for textile dyes [31]. Pigments from selected microfungi (*Curvularia* sp. (green), *Alternaria* sp. (brown), *Phoma* sp. (pink), *Pestalopsis* sp. (purple) were exploited for textile dyes [32]. Production of dyes from *Pencillin*, *Phoma and Curvularia* was tried in optimized medium and continuous production was achieved. Further the production of pigments from selected microfungi is under progress. Simple extraction of dyes was carried out and the dyes were tested for their dyeability in cotton fabrics and developed variety of shades at an industry. The efficacy of the fabric (wash fastness) was tested to find out its suitability [33]. The promising outputs encouraged us to scale up towards precommercialization of microbial dyes to the textile industries.

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