Novel Approaches in Drug Designing & Development
ISSN: 2575-8942

Research Article
Volume 6 Issue 5 - April 2023
DOI: 10.19080/NAPDD.2023.06.555696

Nov Appro Drug Des Dev

Utilization of Yeast Civilizations in the Management of Textile Dyes

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Submission: March 15, 2023; **Published:** April 21, 2023

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Abstract

Urbanization, industry, and population increase all contribute to environmental contamination. Bioremediation is a powerful technique for environmental protection that may be used in a variety of ways. Yeast is one of the most used biomass types for bioremediation of textile dyes at lower pH levels. Yeast is regarded as a low-cost, widely accessible biomass. Bioaccumulations and biosorption procedures were used to remove Reactive Red 11 (RR11) and Acid Green1 (AG1) dyes from living and dead Rhodotorula glutinis (R. glutinis), Pichia pastoris (P. pastoris), and Leucosporidium antarticum yeast cultures in this study. The sulphonic acid groups in AG1 dye are neutralized by the increased concentration of hydrogen ions at lower pH, and the dye's solubility reduces as a result of the neutralization. Bioaccumulation studies using R. glutinis, P. pastoris, and L. antarticum yielded maximum dye uptake percent values of 40.83 percent, 41.66 percent, and 30.28 percent for RR11 dye and 73.21 percent, 55.35 percent, and 41.18 percent for AG1 dye, respectively, at an initial dye concentration of 20mg/l.

Keywords: Yeast; Bioremediation; Textile Dyes; Biomass; Urbanization; Photosynthetic Activity; Bioaccumulations; Carcinogenicity; Genotoxicity; Rhodotorula Glutinis; Pichia Pastoris; Leucosporidium Antarticum; Schizophyllum

Abbreviations: RR11: Reactive Red 11; AG1: Acid Green1; R. glutinis: Rhodotorula glutinis; P. pastoris: Pichia pastoris

Introduction

Urbanization, industry, and population increase all contribute to environmental contamination. Numerous polluted areas across our nation contain significant amounts of hazardous garbage. Organic materials called dyes are used in a range of industries to color final goods. There are 10,000 chemically unique colors made in all. Around 7108 kg of dyestuffs and dye intermediates are produced globally each year, according to estimates [1]. The ecology is harmed when textile effluents containing colors are frequently dumped into aquatic systems, either with or without treatment [2]. When exposed to light, water, oxidizing agents, and microbiological attack, textile dyes are designed to resist fading [3]. A significant portion of these hues were lost throughout the manufacturing and processing processes. It harms the environment because it is wastewater [4]. For instance, the half-life of hydrolyzed blue dye is approximately 46 years at pH 7 and 25°C. Most living organisms are very toxic to dyes, which disturbs the ecology [5]. Aerobic species are impacted by dye pollution because it inhibits sunlight penetration, which in turn lowers photosynthetic activity and dissolved oxygen levels.

Industrial effluents used for dyeing are among the hardest to treat due to their high oxygen and chemical requirements, suspended particles, and toxic compound concentrations, as well as their color, which is the first contaminant the human eye notices [6]. Dye exposure may result in allergic dermatitis, skin irritation, cancer, mutation, and other problems. Furthermore, they have the potential to harm people's livers, kidneys, brains, central nervous systems, and reproductive systems. The toxicity, carcinogenicity, and genotoxicity of textile dye-containing wastewater has made the removal of color from the wastewater more significant than the removal of soluble organic compounds [7]. Physical/chemical approaches are often costly and generate a lot of sludge. More research is currently being done on their biodegradation. Biological techniques have gotten more attention than chemical/physical approaches due to their economic efficiency, lesser sludge output, and environmental friendliness [8]. Because of the cheap cost of transportation and the abundance of water, most textile industries are situated along riverbanks and along coastlines. Water pollution results from the discharge of effluents from these industrial units into different water bodies (rivers, canals, lakes, etc.).

Water pollution is a major issue in developed nations, owing to the development of industry and advanced agricultural technology, which is mostly handled by increasing wastewater treatment systems. However, a lack of technical expertise, a lack

of environmental policy implementation, and a lack of financial resources have created major obstacles [9]. For waste-water treatment, several technologies such as ozonation, photocatalysis, electro-coagulation, precipitation, and adsorption were used. For the removal of synthetic colors from industrial effluents, adsorption methods utilizing adsorbents and biosorption processes using a live or dead biomass are quite effective [10]. When compared to traditional biological process treatment, the key benefits of an adsorption system for water pollution management include excellent removal performance, lower initial investment, flexibility, simplicity of design, ease of operation, and insensitivity to harmful contaminants. Previous studies examined process improvement for Acid Blue 120 dye removal using Aspergillus lentulus using the best process variables, a high dye removal efficiency (99.97%) and uptake capacity (97.54mg/g) were achieved within 24 hours. The decolorization of orange II dye using Phanerochaete chrysosporium. Researchers also tested the capacity of the fungus Trichophyton rubrum to effectively decolorize textile azo dyes and discovered that the fungus T. rubrum is capable of both biodegradation and biosorption of textile colors.

Materials and Methodology

Materials

Acid Green 1 (AG1) (C.I. 10020, Molecular Formula: C30H15FeN3Na3O15S3 and Molecular Weight 878.45; Zmax: 631 nm) and Reactive Red 11 (RR11) (Molecular formula: C24H16Cl2N6; Molecular weight: 459.33; Zmax: 555 nm) dyes were employed in this work. The dye was acquired from Balaji Chemicals, Chennai and was used without any further pre-treatment. Figure 1 depicts the dye's chemical structure. In a standard flask, a 10,000mg/l stock solution was made. Dilution was used to get the necessary concentrations for different investigations (Figure 1).

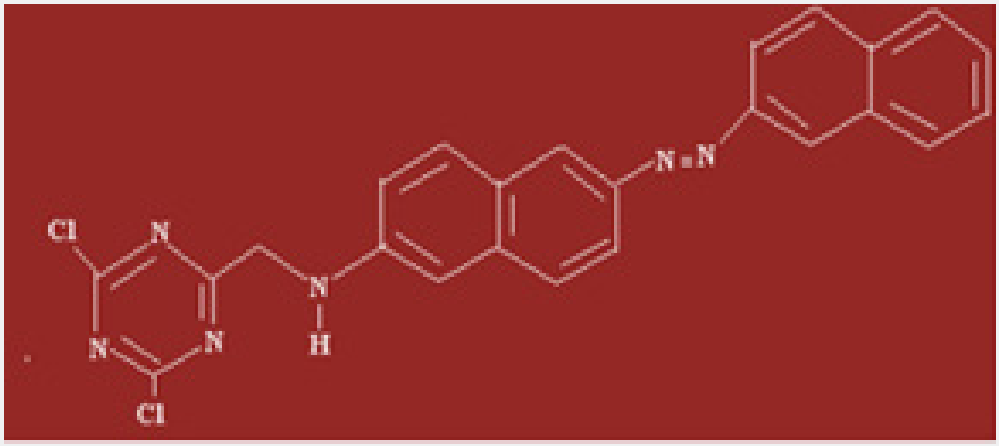

Figure 1: Chemical structure of Reactive Red 11 dye molecule.

Methodology

Organism and culture condition

In this investigation, the yeast strains Rhodotorula glutinis (MTCC number 7312), Pichia pastoris (MTCC 34), and Leucosporidium andarticum were bought from Chandigarh's Institute of Microbial Technology. It was grown at 30°C in Sabouraud Dextrose Broth (SDB) medium and kept in a refrigerator on Sabouraud Dextrose Agar (SDA) slant at 4°C.

Acclimatization

R. glutinis, P. pastoris, and L. andarticum yeast cultures were acclimatized by exposing them to SDB medium containing RR11 and AG1 dye. For acclimatization, the dye concentration was progressively raised from 10 to 100 mg/L. Room temperature was used for the studies.

Bioaccumulation Research

The effect of inoculum volume, beginning pH, and initial dye concentration on the bioaccumulation of RR11 and AG1dyes on yeast cultures was investigated. We looked at the dried cell biomass (X), bioaccumulation concentration (Cacc), maximal dye absorption capacity (qm), and specific growth rate (). The uptake percent is the ratio of the dye's bioaccumulated concentration to its starting concentration. It was calculated using the exponential growth region's slope of ln(X) against time plot.

The effect of inoculum volume on dye bioaccumulation

To achieve a dye concentration of 20 mg/L, the sterile RR11 and AG1 dye solutions were added to the SDB medium. Each 100 mL of dye solution was infected with a volume of initial inoculum ranging from 5% to 25% (v/v). One conical flask was kept as a control, containing just dye in the medium and no yeast organism.

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The flasks were shaken at 150 rpm in a rotary shaker. To precipitate suspended biomass, the samples were collected and centrifuged at 12,000 rpm for 10 minutes. A UV-Spectrophotometer was used to measure the absorbance of the supernatant at the relevant maximum wavelength. The same studies were carried out on *P. pastoris* and *L. antarticum* yeast cultures.

The effect of pH on dye bioaccumulation

In SDB medium, RR11 and AG1 dyes at a concentration of 20 mg/L were created, and the starting solution pH was adjusted from 2 to 7 using diluted HCl and diluted NaOH solution for pH investigations. All the flasks received a 5% inoculum of yeast culture R. glutinis. The flasks were shaken at 150 rpm in a rotary shaker. To precipitate suspended biomass, the samples were collected and centrifuged at 12,000 rpm for 10 minutes. A UV-Spectrophotometer was used to measure the absorbance of the supernatant at the relevant maximum wavelength. The same studies were carried out on *P. pastoris* and *L. antarticum* yeast cultures.

The effect of initial dye concentration on dye bioaccumulation

In each 250 mL Elynmers flask with a pH of 2, dye concentrations of 20, 40, 60, 80, and 100 mg/L were generated as 100 mL in each 250 mL Elynmers flask. All flaks were autoclaved, and each flask received 5% (v/v) of fresh *R. glutinis*. The flasks were shaken at 150 rpm in a rotary shaker. The samples were taken at predetermined intervals of time (0, 6, 12, 24, 36, 48, 60, 72, 84, 96, 104 and 120 hours). To precipitate suspended biomass, the collected samples were centrifuged at 12,000 rpm for 10 minutes. A UV-Spectrophotometer was used to measure the absorbance of the supernatant. The biomass concentration of yeast growth was evaluated by measuring the sample's wet weight using a standard curve of wet weight versus dry cell mass (Aksu 2003). To see whether there were any interactions between the medium and the dye, uninoculated Erlenmeyer flasks containing dye were employed as a control. Each of these studies, as well as the measurements given, were repeated three times. The same studies were carried out on *P. pastoris* and *L. antarticum* yeast cultures.

Results and Discussion

The bioaccumulation of Reactive Red 11 (RR11) and Acid Green 1 (AG1) dyes in *Rhodotorula glutinis*, *Pichia pastoris*, and *Leucosporidium antarticum* live yeast cultures was investigated in batch mode. Dyes bioaccumulation in *R. glutinis* Using *R. glutinis*, the effect of inoculum size on the accumulation of RR11 and AG1 dyes. The accumulation of RR11 and AG1 dyes in R. glutinis was studied using varied inoculum quantities ranging from 5% to 25%. At a 5 percent inoculum volume, the highest dye absorption capacity for RR11 and AG1 dyes was determined to be 2.15 and 23.51 mg/g, respectively. The dye absorption capability was shown to diminish when the inoculum volume was increased from 5% to 25%. When comparing the removal of AG1 dye to the removal of RR11 dye, the dye uptake capacity values were shown to be greater for AG1 dye removal. This data suggests that increasing the inoculum amount has no effect on dye absorption ability. As a result, the ideal value for future trials was set at 5% (v/v) of inoculum volume (Renganathan et al. 2008) (Figure 2).

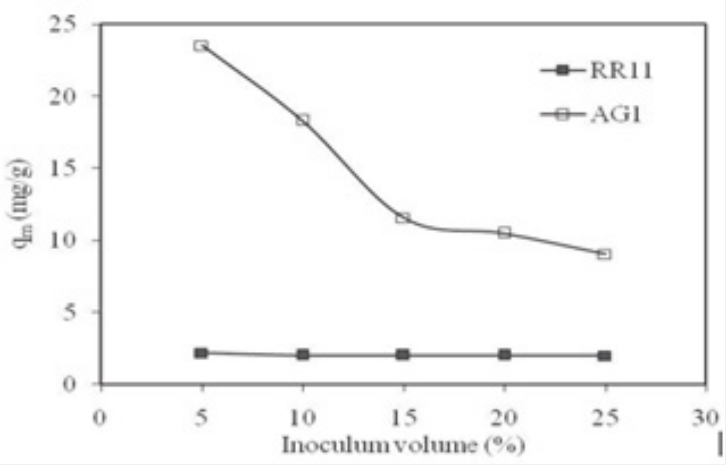

Figure 2: Effect of varying inoculum volume on RR11 & AG1 dyes uptake using R. glutinis.

At diverse starting solution pHs ranging from 2 to 7, the effect of pH on bioaccumulation capacity as well as organism development was investigated. At a pH of 2, maximal dye absorption capacity values for RR11 and AG1 dyes were 4.89 mg/g and 20.91 mg/g, respectively. The maximal bioaccumulation concentrations for the RR11 and AG1 dyes were 14.5 mg/L and 14.64 mg/g, respectively. Table 4.1 shows the dye absorption capacity, bioaccumulation concentration, dye uptake percent, and biomass concentrations

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at various pH levels for the removal of RR11 and AG1 dyes. Throughout the investigation, the pH of the solution was checked, but no significant changes were noticed. When compared to all other pH values investigated in this study, pH value 2 had a better dye absorption capability. Renganathan et al (2006) reported a similar result employing growing Schizophyllum commune for the buildup of Acid Orange 7, Acid Red 18, and Reactive Black 5 dyes. For the removal of RR11 and AG1 dyes, maximum biomass concentrations of 6.27 g/L and 1.4 g/L were achieved at pH 3 in the current investigation. Aksu (2003) earlier reported similar findings utilizing Sacchromyces cerevisiae to remove Remazol Blue, Remazol Black B, and Remazol Red RB. With increases in pH ranging from 2 to 3, the dye absorption percent for the elimination of RR11 dye rose from 40.8 to 72.5 percent. The dye absorption percentage then dropped as the pH values increased from 3 to 7. At a pH of 2, the maximum dye absorption percent for the elimination of AG1 dye was determined to be 73.21 percent. When the starting solution pH value was increased from 2 to 7, the dye absorption capability was found to be reduced (Figure 3).

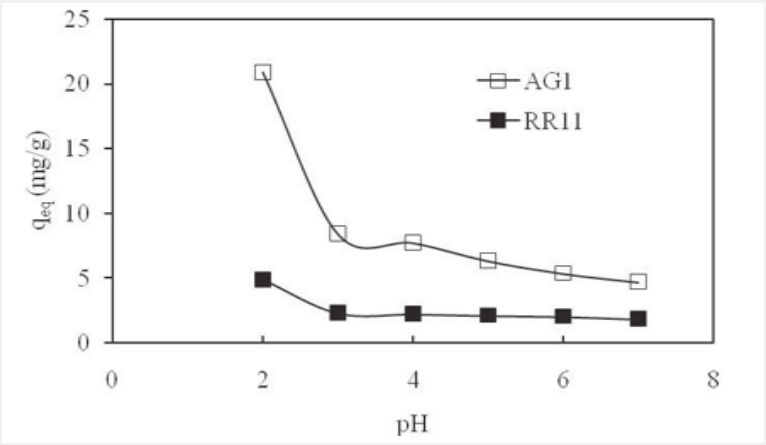

Figure 3: Effect of initial pH for RR11 & AG1 dyes uptake accumulation using *R. glutinis*.

At a pH of 2, the greatest dye absorption capacity was discovered. The sulphonic acid groups in AG1 dye are neutralized by the increased concentration of hydrogen ions at lower pH, and the dye's solubility reduces as a result of the neutralization. Due to electrostatic attraction, the negatively charged dye anions present in the dye solution are absorbed by the positively charged cell surfaces at lower ph.

Conclusion

For the bioaccumulation of RR11 and AG1 dyes utilizing R. glutinis, P. pastoris, and L. antarticum, dye absorption capability was shown to be higher at inoculum volumes of 5%. Using *R. glutinis*, *P. pastoris*, and *L. antarticum* at a 5 percent inoculum volume, the maximal dye absorption capacity was determined to be 2.15, 5.43, and 5.11 mg/g for RR11 dye and 23.51, 6.87, and 8.82 mg/g for AG1 dye. When utilizing *R. glutinis*, *P. pastoris*, and *L. antarticum* at a 5 percent inoculum volume, maximum dye absorption was reported at pH 2 for the bioaccumulation of RR11 and AG1 dyes. *R. glutinis*, *P. pastoris*, and *L. antarticum* were used to get dye maximal absorption capacity values of 4.89, 17.90, and 13.51 mg/g for RR11 dye and 20.91, 19.95, and 13.79 mg/g for AG1 dye, respectively, at pH value of 2. For the bioaccumulation of RR11 and AG1 dyes employing *R. glutinis*, *P. pastoris*, and *L. antarticum* at a 5 percent inoculum volume and an ideal pH value of 2, the maximal dye absorption capacity was determined at 100 mg/L of starting dye concentration. At an initial dye concentration of 100 mg/L, the maximal dye absorption capacity of *R. glutinis*, *P. pastoris*, and *L. antarticum* was found to be 22.22, 30.27, and 23.45 mg/g for RR11 dye and 28.92, 37.18, and 29.22 mg/g for AG1 dye. Bioaccumulation studies using *R. glutinis*, *P. pastoris*, and *L. antarticum* yielded maximum dye uptake percent values of 40.83 percent, 41.66 percent, and 30.28 percent for RR11 dye and 73.21 percent, 55.35 percent, and 41.18 percent for AG1 dye, respectively, at an initial dye concentration of 20 mg/l when compared to RR11 dye, AG1 dye accumulated well in all three yeast cultures (*R. glutinis, P. pastoris, and L. antarticum*).

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