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Adsorption of Acid Brown-340 on Silica Based Adsorbent

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Abstract

Acid Brown-340 is a valuable and prominent dye which Having Serious effect our environment due to its acidic nature. Usually, this dye is coming out of different industries and accumulate in various water bodies such lakes, ocean and fresh water ecosystem. In this Present study silica monolith particles were synthesized by the renovated sol-gel process under controlled environment of heating steps. The newly prepared functionalized silica monolith particles were used as an adsorbent for the removal of acid brown-340 from aqueous solution. Particles originating from silica monolith were effective adsorbent for the removal of selective dye due to its various sorts such as enlarged surface area, high permeability due to monolith like nature leading to high loading capability, and mechanical strength to various PH. Adsorption capacity of silica was firm with respect to different parameters at certain point of time. By adjusting certain parameter such as PH at range 2-8 Concentration taken as range from 0.02-0.1 and time as taken as range from 15mins to 75mins. Then Acid brown-340 shows the greatest adsorption with particles originating from silica monolith when the optimized values of the parameters for acid brown-340 are PH is 2, adsorbent dose is 0.06g, and Contact time is 75 min.

Keywords: Adsorption, Acid Brown-340, Adsorbent, Silica Monolith, Adsorbate, Water Treatment

1. Introduction

Dyes are mainly chemical compounds that can assign themselves to surfaces or stuffs to impart color. The majority of dyes are complex organic molecules that must be impervious to a variety of aspects, including detergent act. Synthetic dyes are broadly used in a variety of fields of advanced technology, such as textiles. More than 10 000 types of Dyes in the environments for example methylene Blue, Acid Red, Congo Red, Acid brown 340, Acid Brown 98 and Many others all are Carcinogens [1].

Dye-containing waste water not only pollutes surface and groundwater, but it also harms human health and disturbs the environment. Many dyes are resistant to fading due to their high thermal and chemical stability. Textile and protective wastes are two of the most polluting industrial wastes, and the issues of treatment and removal of such wastes need a great deal of attention. Because most dyes are light and heat stable and are not biodegradable, it is difficult to remove them from effluents [2].

Figure 1: Structure of Dye

Wastewater from industries polluting water bodies with toxic pollutants at concentrations faraway beyond the World Health Organization's (WHO) limits. Synthetic dyes are widely used, with over 100,000 varieties currently on the marketplace. The entire yearly production of these dyes is nearly 7 105 – 1 106 tons, and nearly 10–15 percent of unused dyes reach the ecosystem through wastewater from textile, plastic, cosmetics, grin.

And Removal of waste water from industries into the environment can pollute freshwater reservoirs, dissembling hazardous effects on the environment and human beings. If dyes are exposed to the skin or swallowed, they increase the risk of skin cancer and other skin complications such as allergies, irritation, and sensitization. Dyes are toxic, cancer-causing, and cause genetic problems [3].

Due to the environmental and health fears related with wastewater sewages, a wide range of procedures for removing dyes has been developed and used, which can be considered into three main categories: chemical, physical, and biological methods. Membrane filtration, coagulation and flocculation, sedimentation, chemical precipitation, ion exchange, and adsorption these all are some of these conventional techniques [4].

Various other analytical methods are also used such as G–MS, L-MS, and HL-DD, have been established for the detection of dyes. These hyphened techniques are pretty advanced and give fast and precise results but have many also drawbacks such as high cost, Complex instrumentation, and use of organic regents [5].

However, mostly researcher were desire to work on these techniques because of the extra benefits and ease of use, We prefer this process of Adsorption, as a combination of physical-chemical methods, is found to be the most favorable and cheaper method to Remove dye pollutants This method has been extensively accepted as one of the most effective waste treatment techniques for removing hazardous inorganic and organic pollutants because it is fast, inexpensive, effective, and is ease of use [6].

Different Teqniques for Removal of Dye

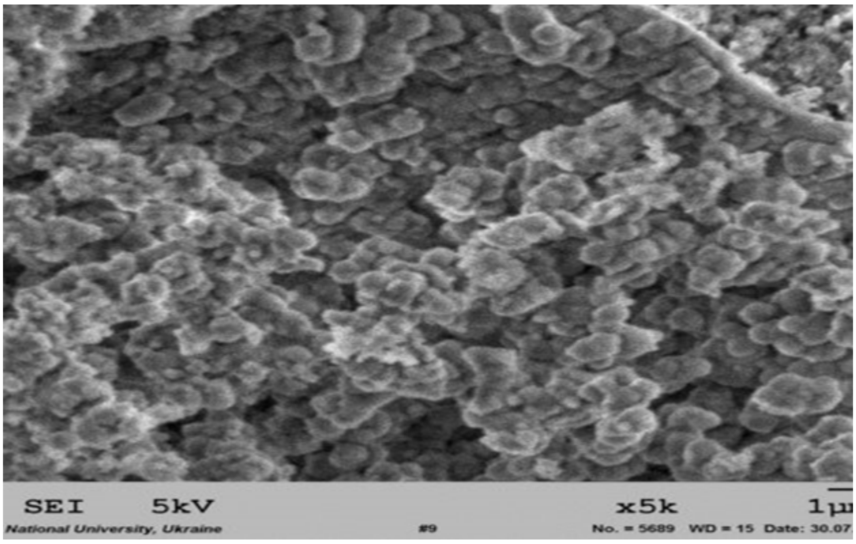

Figure 2: Picture of Silica Monolith

1.1. Process of Adsorption

However, because of the additional benefits and ease of use, we prefer this process Adsorption, as a combination of physical-chemical methods, is found to be the most favorable and economic method to Remove dye pollutants This method has been widely accepted as one of the most effective effluent treatment techniques for removing hazardous inorganic and organic pollutants because it is fast, inexpensive, efficient, and is easy [7].

Adsorption has been reported for the removal of heavy metals, dyes, odors, oils, and other organic pollutants in waste effluents and all other organic Various adsorbents Activated carbon, perlite, bentonite, silica gel, fly ash, lignite, peat, and silica have been utilized for the removal of various pollutants from aqueous solutions [8].

1.2. Effect of adsorption process on environment

Quality Due to its low cost, simplicity in design and operation, and environmentally friendly behavior, the Adsorption process is known to be an effective separation technique. The type of adsorbent has a direct impact on the efficiency of adsorption. Numerous studies have been conducted in recent decades on low-cost, biopolymer-based Nano-composites as an effective adsorbent. [14It is necessary to develop cheap and easily available adsorbents with high adsorption capacities in order to improve the efficacy of the adsorption processes. Hitosan has been associated with a high potential for the adsorption of anionic dyes. The literature revealed that the adsorption capacities of reactive dyes in neutral medium on chitosan were approximately 1000–1100 mg g 1. Among these, adsorption is the most popular, owing to its high effectiveness, economic viability, and ease of operation. Activated carbons,4 silicas, 5 and other well-known examples of commercial adsorbents are three well-known examples of commercial adsorbents [9].

Removal is possible through best Adsorbent name is silica monolith through Adsorption process a well-known Adsorbent for removal process. Many studies have observed into the synthesis of well-ordered mesoporous aluminosilicates or Silica Monolith, including direct synthesis and post-synthesis methods. Direct synthesis, for example, has the advantage of varying the l/Si ratio, A few examples of the use of silica monolith also contain the Removal of waste from water through adsorptions process. Organic-modified silica monoliths are also used to remove heavy metals from waste water. Because of their harmfulness, the removal of these compounds by means of adsorbent materials is of environmental concern and a great issue for human health. Due to these properties Because Silica Monolith is a porous materials possess high surface area [10].

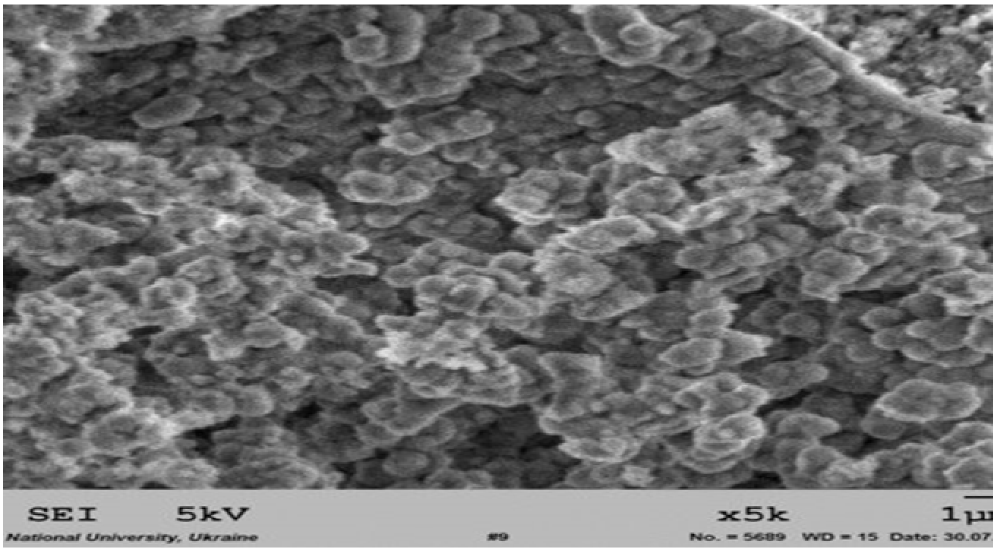

Figure 3: Picture of Silica Monolith

2. Materials & Methods

2.1. Chemicals and Materials

Acid brown 340, Distal water, Silica Monolith Adsorbent, Boric Acid (H3BO3), Phosphoric Acid, (H3PO4), Acetetic Acid (CH3CHOOH), Hydrochloric Acid (HCL), Sodium Hydroxide (NaOH), Buffer Solution, Round Bottom Flask, Beakers, Pipette, Spatula, filter Paper, Stand, Dropper, 25ml Flasks, funnel, 100 ml Graduated Cylinder, Desiccator, 100ml flask, Tubes, Volumetric Flask, Reagent Bottle, Lab Coat, Glows, Mask, Computer (Recorder) Micro Syringe.

2.2. Silica Monolith.

Many studies have looked into the synthesis of ordered mesoporous aluminosilicates or Silica Monolith, including direct synthesis and post-synthesis approaches. Direct synthesis, for example, has the advantage of varying the l/Si ratio, but it is difficult to control the reaction due to different hydrolysis and condensation rates of aluminum and silicon precursors.

Meanwhile, in the post-synthesis route, the aluminum incorporates into the inner will of the silica without disrupting the ordered structure of the silica framework; however, it is constrained by its loading amount and contains certain by-particles. Chromatography for column preparation However, recent examples report on their use in the removal of chemical compounds such as fatty acids, phenols, and sterols from wastewater effluents: After the inclusion of biomolecules or enzymes, they are mainly exploited as composite or biocomposite materials in these cases.

A few examples of the use of silica monolith also include the preparation of composite or functionalized materials for 2 adsorptions. Organic-modified silica monoliths are also used to sequester heavy metals and to immobilize enzymes. Because of their toxicity, the removal of these compounds by means of adsorbent materials is of environmental concern and a relevant issue for human health. Several recent studies fused on the use of mesoporous ordered silicas, functionalized with organic groups, for the adsorption of VOCs.

The toluene adsorption properties of different porous silicas (i.e., fumed silica, SBA-15 and commercial MCM-41) have been recently reported by our group and we have shown that the porous architecture of different silicas have in important effect on the final adsorption properties. In the same conditions, we also tested the adsorption behavior of siliceous zeolites and hypercross-linked polymers.

We derived that whereas siliceous zeolite adsorbs 21 Q% of toluene, HyperCross-linked Polymers (HCPS) with flexible structures are able to silica monoliths have been used in applications mainly related to the field of adsorb more than 140 Q% of toluene.

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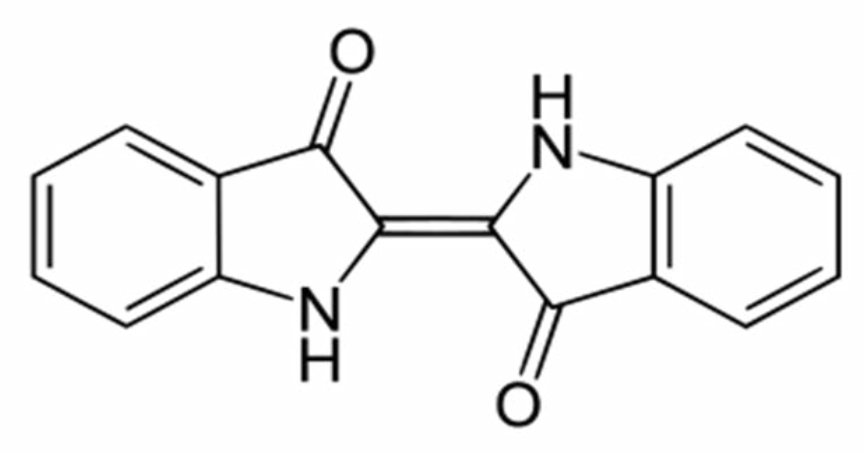

Figure 4: Structure of Acid Brown-340 dye

2.3. Adsorbate

The acid Brwon-340 dye used as adsorbate. Their molecular formula is C30H20O12N8S2Na2. The molecular weight of acid brown-340 is 794.64.

Acid Brown 340 is a versatile dye known for its rich and earthy brown hue, making it widely used in the textile and leather industries. Renowned for its excellent color fastness, this dye ensures vibrant and long-lasting results on various materials. Acid Brown 340 is particularly favored for its ability to create warm and appealing tones, adding a touch of sophistication to fabrics and leather products. Its chemical properties make it adept at bonding with fibers, resulting in consistent and resilient coloration. With its reliability and aesthetic appeal, Acid Brown 340 stands out as a preferred choice for achieving enduring and captivating shades in the world of dyes.

Acid Brown 340

Figure 5: Picture of Acid Brown-340 dye

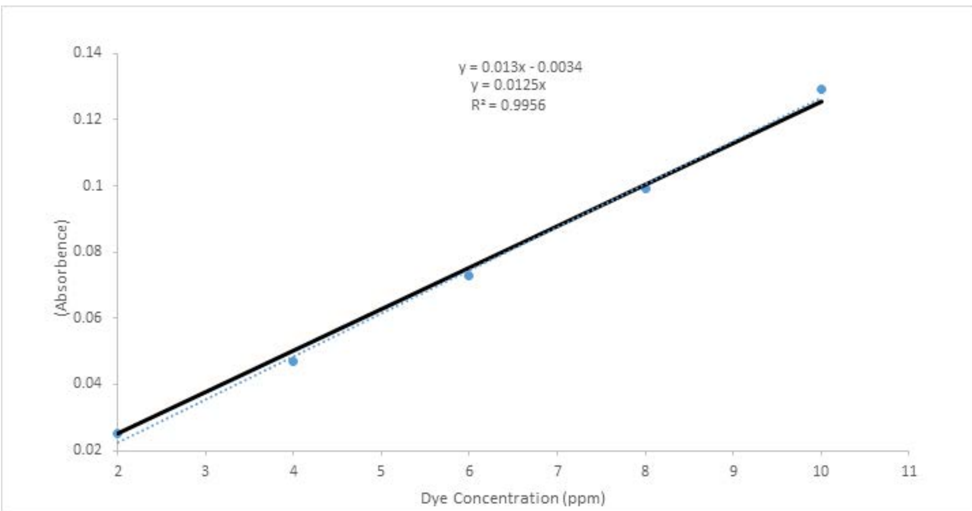

Figure 6: Picture of Acid Brown-340 dye

2.4. Instruments

Digital Balance (BSA2245), Oven (BOV-V30F) Shaker (001) UV spectrophotometer (UV 1900) spectronic 20(SP-300) Cuvettes (100-40-10) Water Bath (DSB-1000D) PH meter (Hanna),

2.5. Experimental work performed in laboratory.

❖ **Preparation of Different Solution to Study Different Parameter**

- Synthesis of Porous Polymer-Based Monolith Adsorbent
- Stock solution for Batch Study
- Dilute Solution
- Buffer Solution to maintain PH
- Optimization Study
- Solutions having Different PH
- Solutions Having different concentration of adsorbent
- Solutions having Different Times

❖ **Analysis Performed in Laboratory.**

- Calibration curve
- PH Study
- Concentration Study
- Contact Time Study

2.6. Experimental Worked Performed Procedures

Synthesis of porous polymer-based monolith:

Synthesized a porous polymer-based monolith by in-situ polycondensation of epoxy monomer bisphenol A diglycidyl ether and ethylenediamine in the presence of pore-forming reagent (polyethylene glycol) and used it for the preconcentration and determination of Pb2+ ions using flame atomic absorption spectroscopy. The authors found that the maximum adsorption capacity of Pb2+ ions onto the formed monolith was 106.8 mg g–1. They rerated that the formed monolith exhibited superior reusability and stability. They concluded that the formed monolith is suitable for the preconcentration of Pb2+ ions as an ion-selective solid-phase extraction adsorbent.

Preparation of Stock/Batch Solutions for Experiments: 100ml stock solution (100ppm) of acid brown-340 was prepared using acid brown-340.For preparation of stock solution 0.01g of acid brown-340 were dissolved in 100ml flask by addition of Distilled water.

Dilute Solutions.

5 different Solutions were prepared from stock solution using the standard Dilution formula. Batch Experiments were carried out to explore the dye removal efficiency from synthetic solution.

Dilution formula. $C_1V_1=C_2V_2$.

Buffer Solution.

For preparation of buffer solution, first 0.04 molar solutions of boric acid, acetic acid and phosphoric acid were prepared. 0.04 molar solution of boric acid was prepared by dissolving 0.24g of boric acid in 100ml of distilled water. The same process was repeated for 0.447ml of phosphoric acid and 0.22ml acetic acid.

Optimization Study.

Adsorption process was optimized for important parameter like PH, adsorbent dose, and contact time by changing the parameter under observation while keeping other parameters and accordingly optimum value of each parameter for maximum removal of dye ion was determined.

Adsorption [%]

The Removal percentage (R%) or % Adsorption is the Defined as the Ratio of Concentration before Adsorption to Ratio of Dye Concentration After Adsorption Process (Ci-Cf) to initial concentration of Dye in aqueous Solution. It was being calculated following Formula.

R (%) Removal = (Ci-Cf)/Cf

R%: Removal Percentage of Dye or Percent Adsorption

Ci: initially concentration before adsorption (Mg /L)

Cf: Final concentration After Adsorption (Mg /L)

PH. Solutions.

PH of the different solutions was maintained and adjusted range from 2 to 8 with the addition of Buffer solution prepared in laboratory, Buffer solutions of acetic acid, phosphoric acid, and boric acid were used to maintain PH of the solutions. The solutions were prepared both in acidic medium and basic medium. Shaking and filtration were carried out for further analysis.

Concentration solutions.

Solutions having different adsorbent dose were prepared in 100ml flask by adjusting range from 0.02g to 0.1g. Different Adsorbent concentration and 2ml of dye both were dissolved by addition of distilled water. Shaking and filtration were carried out for further analysis.

Time solutions.

Solutions having different contact time were prepared in 100ml flask by adjusting range from 15mins to 75mins. 0.02g of adsorbent and 2ml of dye both were dissolved by addition of disttled water. Shaking were carried out between adjusting range. Filtration was carried out for further analysis [11-60].

3. Discussion and experiments.

Calibration curve: A Calibration is also Known as a standard Curve, is a general Method for Determining the concentration of a substance in an Unknown sample by comparing the unknown to a set of standards of known concentration. The effect of concentration on Absorbance was studied using UV-Spectrophotometer by Preparing Different solutions having concentration of dye with range from 2ppm to 10ppm. Result showed in table 1.

Initial Dye Conc: 2ppm to 10ppm

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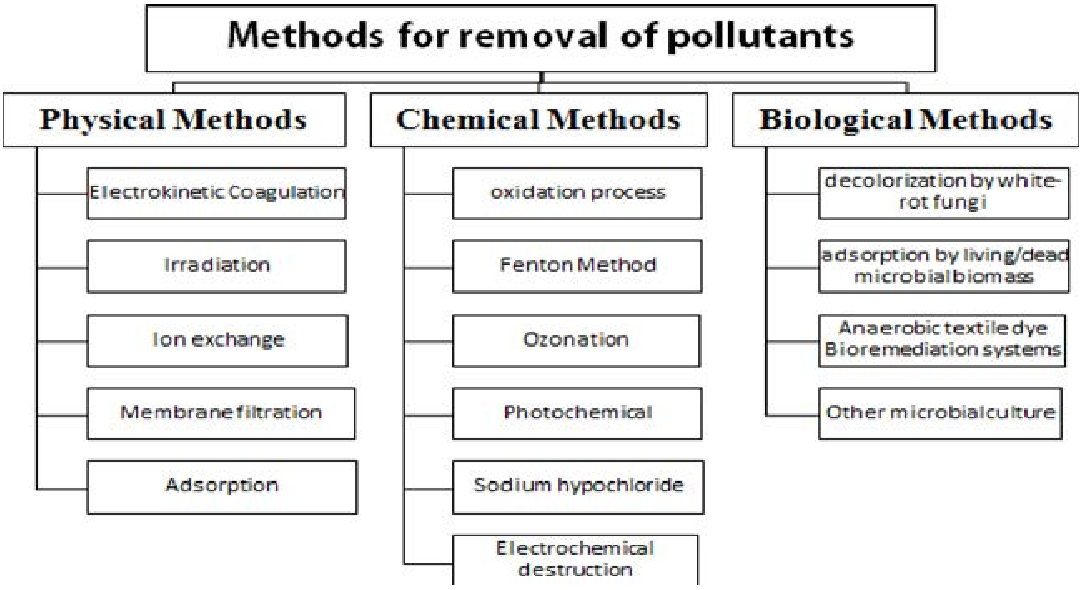

Table 1: of Calibration carve

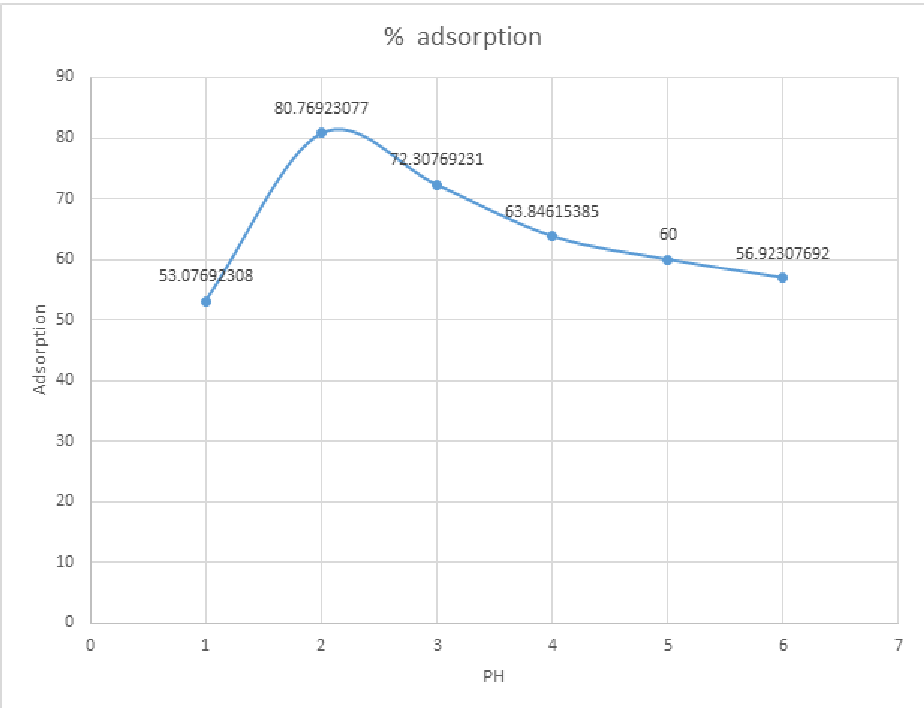

Figure 7: Effect of PH on Adsorption

The effect of PH on the Adsorption of Acid Brown 340 on silica based Adsorbent originating from Silica Monolith was studied at PHs ranging from 2 to 10, while all other parameters remained constant. The results and effects of Ph. on adsorption are shown in Table, and the best adsorption was seen at PH 2 in the acidic range. Because dye was acidic in nature. The adsorption of dye increased particularly up to PH 2 and decreased. It might also be possible that the surface of sorbent might remain more stable at PH 2 rather than highly acidic medium between (1to 2) PH.

Dye adsorption strongly dependent upon the PH. The Change in the potential between sorbate and sorbent may be protonation and deprotonating of the groups attached to the adsorbent. In acidic medium the presence of functional groups on the surface of the adsorbent is positively charged due protonation of strong acidic solution and hence negative sites of anionic dye can easily approach to positively charged surface of the adsorbent and increase the effectiveness of adsorbent acid brown-340 dye while in the basic range adsorption get Decreased due to nature of dye is acidic Data was Showed in Table 2.

PH range: 1 TO 10 Adsorbate: 2ml Adsorbent: (w) 2 g/L

%ADSORPTION

Table 2: Effect of PH on Adsorption and % Removal of Acid-Brown 340.

Concentration (ppm)(mg/l)	Absorbance
2	0.025
4	0.047
6	0.073
8	0.099
10	0.129

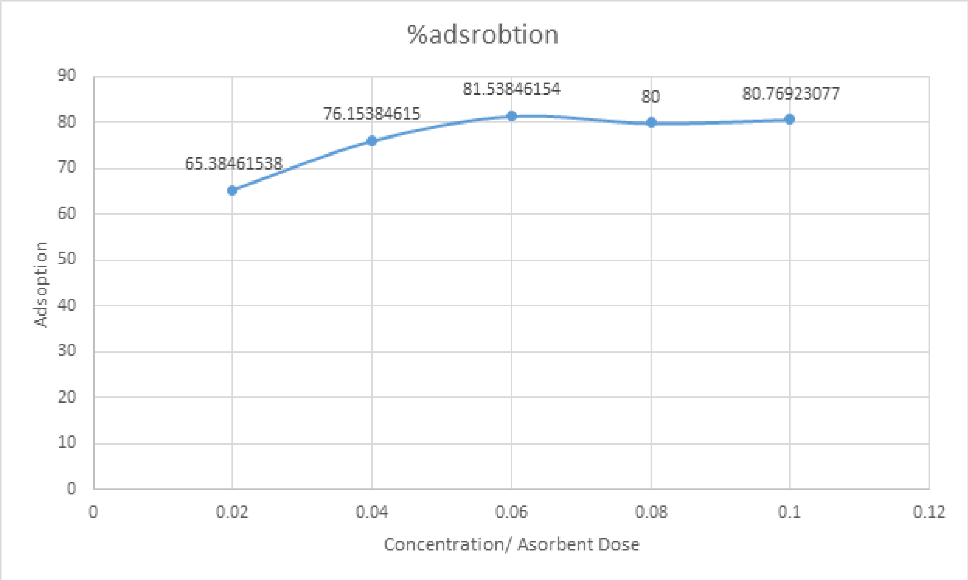

Figure 8: Effect of PH on Adsorption

Effect of adsorbent dose on adsorption: The effect of Adsorbent on the Adsorption of Acid Brown 340 on Silica based adsorbent originating from Silica Monolith was studied at ranging from 0.02g to 0.1g, of adsorbent. While all other parameters remained constant. Shaking was carried out for 30mins and then filtration was taken out followed by filtration process. Filtrate were collected for batch analysis for every Solutions. The best adsorption was observed at 0.06g (6mg). The result of adsorbent dose on adsorption is showing in Table 3.

Initial Dye Conc: 100ml = PH Range: 2 = Shaking Time 30 min = shaking speed 200rpm = Temperature: 313 K

%ADSORPTION

Table 3: Effect of Adsorbent Dose on Adsorption % Removal of Acid-Brown 340.

S.NO	PH	(%) Adsorption
01	1	53.07
02	2	80.7
03	4	72.3
04	6	63.8
05	8	60
06	10	56.9

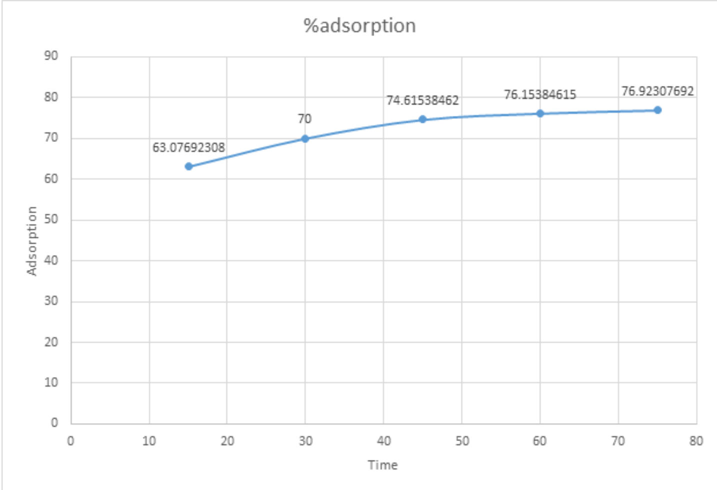

Figure 9: Effect of Adsorbent Dose on Adsorption Effect of Contact Time on Adsorption.

The effect of contact time on the Adsorption of Acid Brown 340 on Silica based adsorbent originating from Silica Monolith was studied at ranging from 15mins to 75mins, while all other parameters remained constant. The Adsorption proportion of dye was high due the presence of adsorbate vacant site on sorbent surface after that adsorbate molecules entering into pores of inner surface which was comparatively slow process. Then the equilibrium is established, and the process remain constant. The best adsorption was seen on 75mins. The result were Showed in Table 4.

Initial Dye Conc: 100ml = PH Range: 2 = shaking speed 200rpm = Temperature: 313 K
Adsorbent Dosage: 2g/L

%ADSORPTION

Table 4: Effect of Contact Time on Adsorption % Removal of Acid-Brown 340.

S.NO	CONTACT TIME(mins)	%Adsorption
1	15	63
2	30	70
3	45	74.6
4	60	76.1
5	75	76.9

4. Conclusion

To sum up, this study specifies that the particles originating from fused Silica monolith can be successfully used for removal of Acid brown-340 from aqueous media, and also shows the efficiency of Adsorption method for the removal of dyes. Different parameter was checked which Effect adsorption process such as contact time, adsorbent dose and PH. The optimum PH for acid Brown-340 was 2 contact time 75, adsorbent dose 0.06g and concentration 10ppm.

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