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Treatment of Wastewater Containing Hazardous Pollutant-Phenol Generating From Resin Manufacturing Industry by Adsorption

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Abstract - *In the last few years, Phenol formaldehyde resin is used predominantly in the wood based product manufacturing industry as adhesives. The Global Phenolic Resin Market is projected to register a CAGR of 4% during the forecast period (2021-2026)[1]. As global Phenolic Resin Market growth projected with CAGR it would be increased generation of wastewater containing hazardous substance "Phenol" too. Regulatory concerns and stringent environmental policies compelled the resin manufacturing industries to reduce the phenol concentration up to the acceptable limit. Generally physical-biological treatments are provided to the effluents coming from various industries. These specific pollutants like phenols are not easily degradable are commonly toxic so their discharge can cause damage to the environment, and achieving legal purification levels is often very difficult. There are various methods available for the treatment of phenol in waste water like, photo catalytic degradation, extraction, bio-sorption, wet air oxidation, biological oxidation, advanced oxidation, adsorption and membrane processes. Adsorption is observed very effective and easy method for Phenolic pollution. In this report, research of the adsorption potential is to be done for numerous adsorbents for getting rid of Phenol contaminants wastewater generating from resin manufacturing plant. The adsorbents taken into consideration are activated carbon, modified clay of bentonite, unmodified bentonite clay, treated fly ash and saw dust carbon. Effect of various parameters like adsorbent dose and initial concentration are studied for phenol adsorption on activated carbon. The equilibrium effects are correlated through isotherms like Freundlich isotherm and Langmuir isotherm.*

Key Words: Adsorption, Phenol, Resin, Isotherm

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I. INTRODUCTION

Water is the one of the valuable resource in nature, and due to its realization becoming prevalent source of concern, core attention and emphasis is placed on its maintenance and purification than ever before. People are concerned about the causes that have negative impact on the environment. Industries are also very distinguished in these days's society and its impact on water increases substantially. Increasing regulatory concerns as well as stringent environmental policies compelled industries for adequate waste water treatment facilities to treat their effluents as per specification of the pollution control board.

Generally conventional effluent treatment process like physico-chemical and biological treatments are provided to the effluent coming from various industries. Some specific effluents from industrial production processes may be difficult to purify by traditional waste water treatment technology, as a result of the complexity of some of their components. These specific components, which are not easily degradable, are commonly toxic and their discharge can cause serious problems to the environment, sometimes even achieving legal purification levels is often very difficult. Adsorption processes have been proven to be one of the most effective methods for the removal of Phenolic compounds.

Adsorption is used for reduction of various organic and inorganic pollutants coming out from industries such as dye stuff industry, chemical industry, textile industry, petrochemical industries, refineries, pharmaceutical industry, pulp and paper industry, etc. by using adsorbent like activated carbon, wood charcoal, clays, clay minerals, synthetic adsorbent, inorganic oxides/hydroxides, chitin and some low cost non conventional adsorbent. Adsorption can be used for removal of color, Phenolic compounds, heavy metals and other organics. Adsorption can be applied widely for industrial waste water treatment as well as for domestic water or natural water treatment. Adsorption can also be used as the first stage of treatment that shall increase efficiency of the subsequent biological treatment.

Generally adsorption is used as a tertiary polishing treatment has demonstrated the adsorption as the first stage of treatment that shall increase efficiency of the subsequent biological treatment. For removal of phenol and

Phenolic compounds activated carbons (powdered activated carbon and granular activated carbon) are most commonly used adsorbents. Higher removal efficiency for phenol and Phenolic compounds from waste water is attainable by using such conventional adsorbents. Thus adsorbents can be used as common adsorbent for treating effluent containing mixture of such Phenolic compounds. Due to the harmful effects of phenols on human and aquatic life phenol is emphasizing pollutant for the study in this project work. Adsorption is clean and easy technique for the waste water.

1.1 INTRODUCTION TO PHENOLIC POLLUTANT

Phenols are considered as priority pollutants since they are harmful to organisms at low concentrations and many of them have been classified as hazardous pollutants because of their potential harm to human health. CPCB call for lowering Phenolic compounds concentration less than 1-5 mg/l for effluent discharged from petrochemical industries and Refineries. Phenols cause an increase in oxygen demand in water and they also impart a taste to drinking water with even minute concentrations of their chlorinated derivatives.

Phenols in the waste water generally consist of a variety of hydroxyl benzenes, substituted hydroxyl benzenes and are not readily biodegradable. They are toxic and are potential health hazards.

II. EXPERIMENTAL PROCEDURE AND SET UP

- **Activated carbon (AC)**

Activated carbon was brought from Terraquaer Chemicals. Activated carbon washed several times earlier than use and then it turned into dried in muffle furnace at eighty-eighty five °c for 2 hr for elimination of moisture. After drying keep it in desiccator for cooling.

- **Activated Fly Ash**

Fly ash was brought from Ambuja Intermediate. Fly ash became washed numerous instances in distilled water. Fly ash was combined with 0. 1N HCl for the activation purpose. After washing it in distilled water several instances and it become kept for drying, in the sun light and saved in muffle furnace for two hr at 50 °c for elimination of moisture. Then it put into desiccator for cooling.

- **Saw Dust Carbon**

The Saw dust was washed several times with distilled water to remove the earthy material and other impurities. Then after; saw dust was boiled with distilled water and supernatant solution was poured off. This process was repeated several times, until clear supernatant solution is obtained. The washed adsorbent was dried in a muffle furnace at 80 °C. After the drying the saw dust was carbonized at 700 - 750 °C in muffle furnace for 1 hr in oxygen deficient atmosphere. It was cooled in desiccator and stored in tight container.

- **Na-Bentonite**

Pure bentonite was brought from Bhavnagar. The bentonite was then enriched with 1N NaCl solution, and then washed several times with distilled water until it is chloride free. This can be checked by the addition of AgNO3 after washing with distilled water to make sure that no precipitate is formed, which is the evidence of chloride existence. The solid particles was separated by the filtration and dried at 70 °C.

- **Thermal Bentonite**

It is a one type of physical treatment. The Na-bentonite was heated up to 850 °C for 30 min in a muffle furnace. Then it was cooled in desiccator and stored for further use for the adsorption tests.

- **Phenol Containing Wastewater sample**

A sample of phenol containing wastewater is brought from M/s. Sundek India Ltd, located at Rajpur, Dist: Mehsana. M/s. Sundek India Ltd is engaged in mfg. of phenol formaldehyde resin. A raw ample is diluted for study purpose at lab scale.

- **Analysis Method**

4-Aminoantipyrine method using Spectrophotometer

III. ADSORPTION ISOTHERMS

Adsorption is a dynamic competition among the molecules in the feed for a position on the surface of the adsorbent. The more strongly adsorbed molecules will displace the more weakly adsorbed molecules from the surface of the feed solid until equilibrium is established with the composition of the feed stream. The relationship between the amount of material adsorbed and its concentration in the feed in equilibrium with the adsorbent is called an adsorption isotherm.

3.1 Freundlich Isotherms:

The Freundlich equation is an empirical expression that encompasses the heterogeneity of the surface and the exponential distribution of sites and their energies.

The empirically derived Freundlich equation is defined as follows:

X/M =KFCe1/n
Where, K and n are empirical constants
Co = Initial concentration of solute (mg/l)
Ce = the final concentration of solute in solution at equilibrium
X = Co – Ce (mg/l)
M = concentration of adsorbent (g/L)
For linearization of the data, the Freundlich equation is written in logarithmic form:
log (X/M) = log KF + 1/n logCe.
Here the linear line obtained gives a slope, which is the value of 1/n, and the y-intercept is log KF. The intercept is an indicator of adsorption capacity and the slope of adsorption intensity.

3.2 Langmuir Isotherms:
Langmuir's model is characterized by the following conditions:

- The molecules are adsorbed on definite sites on the surface of the adsorbent
- Each site can accommodate only one molecule (monolayer)
- The area of each site is a fixed quantity determined solely by the geometry of the surface
- The adsorption energy is the same at all sites. In addition, the adsorbed molecules cannot migrate across the surface or interact with neighboring molecules.

The Langmuir adsorption isotherm is expressed as:

X/M = Q =Qo (b Ce / 1+ b Ce)

Where,

Ce = aqueous phase equilibrium concentration (ppm)
Qe = adsorbed phase equilibrium concentration (mg/g)
Qo = is the maximum adsorption capacity when complete monolayer forming on the surface and
b = Langmuir constant

By rearranging the equation to,

(Ce/Qe) = (1 / b Qo) + (1 / QoCe)

A plot of Ce/Qe vs. Ce would give Qo and b from the slope and the intercept respectively.

4. RESULTS AND DISCUSSION

A sample of phenol containing wastewater is brought from M/s. Sundek India Ltd, located at Rajpur, Dist: Mehsana. M/s. Sundek India Ltd is engaged in mfg. of phenol formaldehyde resin. A raw ample is diluted up to initial phenol concentration of 300 mg/l for study purpose at lab scale. The equilibrium data was obtained for experiments for initial phenol concentration of 300 mg/l and with the aid of the use of various adsorbents Like Activated Carbon (AC), Treated Fly Ash (FA), Saw Dust Carbon (SDC), Na-Bentonite (NaB) and Thermal Bentonite (TB). The graph derived from the data for Freundlich and Langmuir isotherm and for all adsorbents are as under.

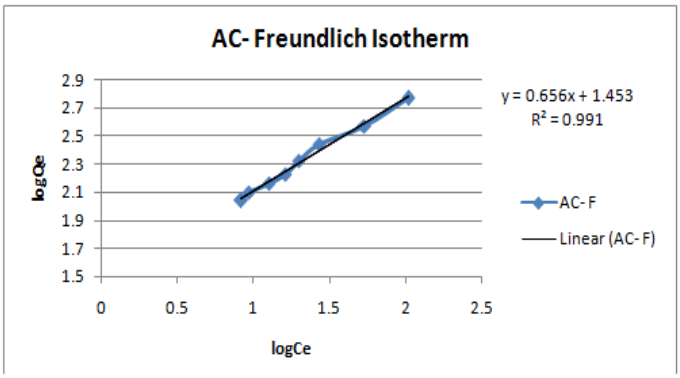

Figure 1: Freundlich Isotherm for AC

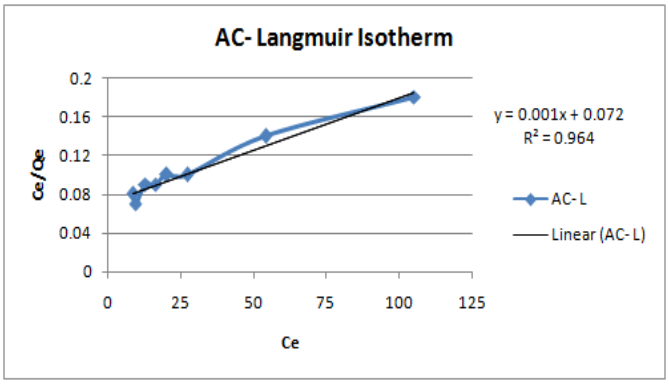

Figure 2: Langmuir Isotherm for AC

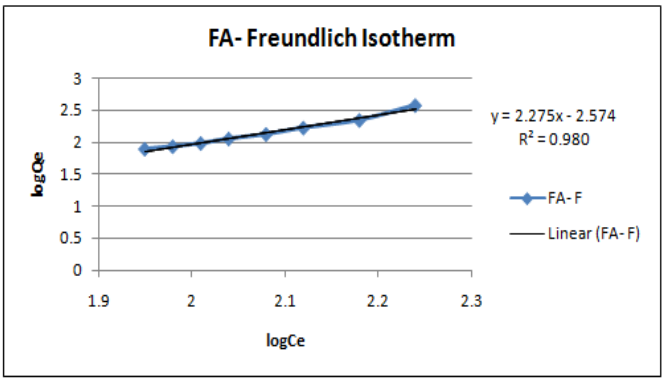

Figure 3: Freundlich Isotherm for FA

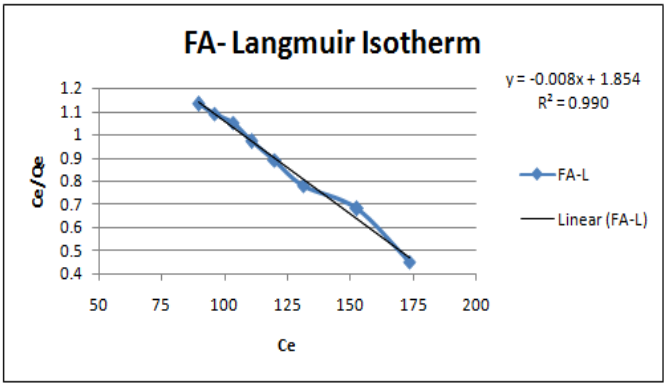

Figure 4: Langmuir Isotherm for FA

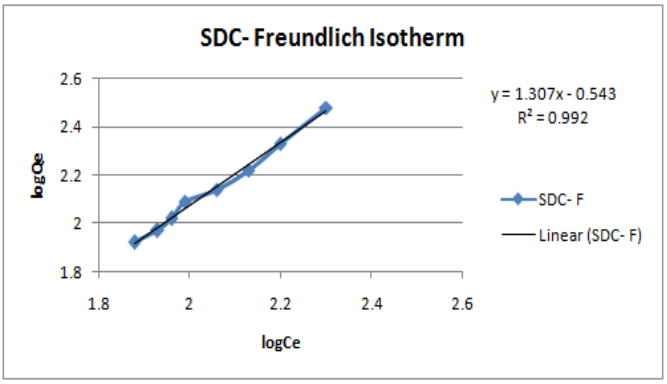

Figure 5: Freundlich Isotherm for SDC

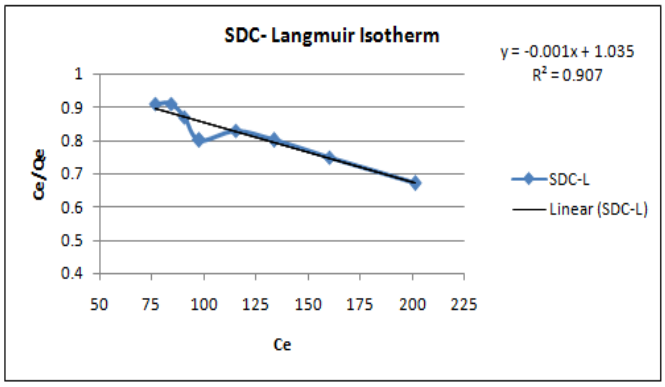

Figure 6: Langmuir Isotherm for SDC

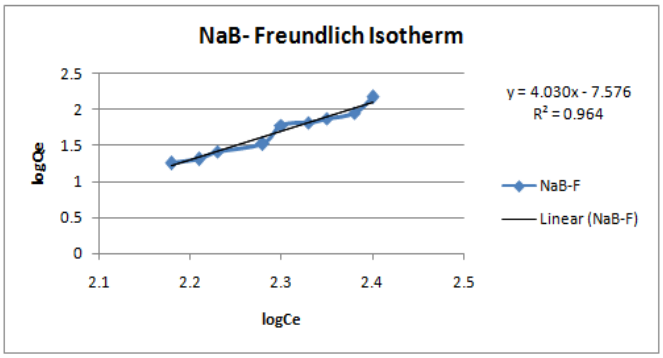

Figure 7: Freundlich Isotherm for NaB

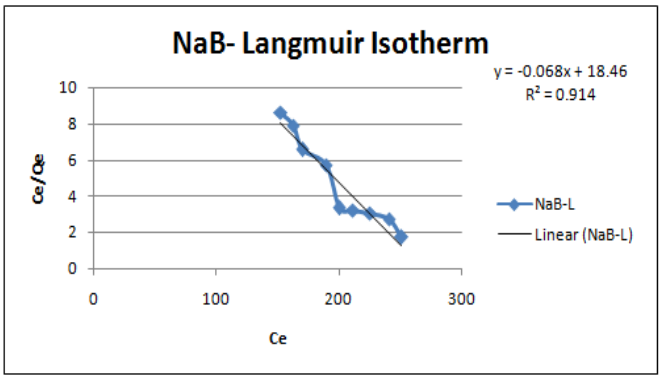

Figure 8: Langmuir Isotherm for NaB

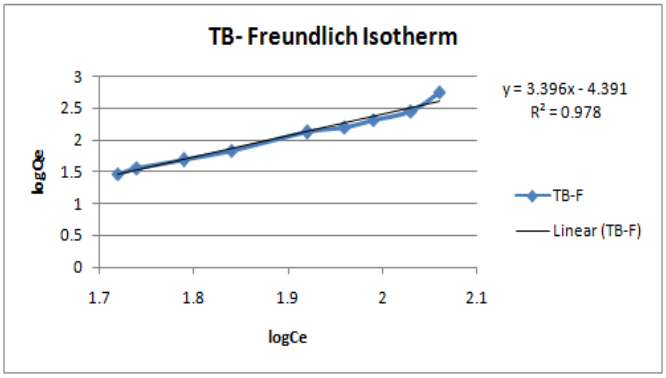

Figure 9: Freundlich Isotherm for TB

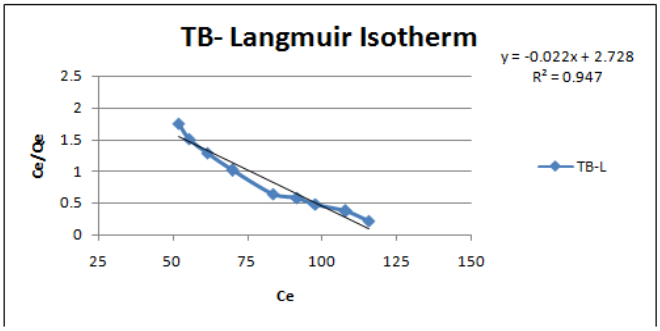

Figure 10: Langmuir Isotherm for TB

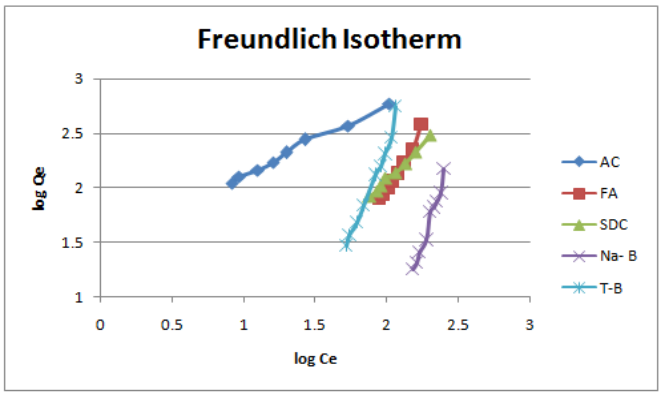

Figure 11: Freundlich Isotherm for all adsorbents

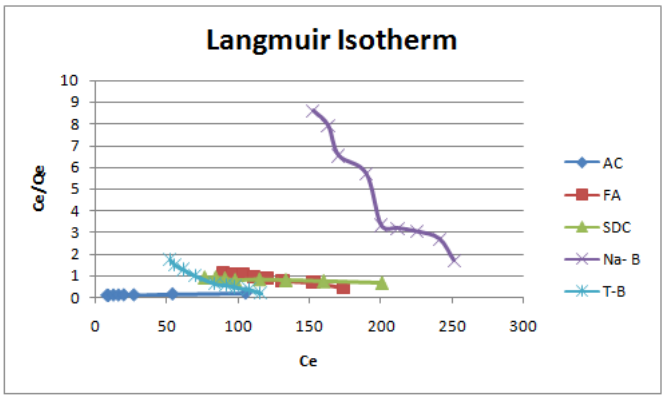

Figure 12: Langmuir Isotherm for all adsorbents

The comparison was done by Freundlich isotherm and Langmuir isotherm. The isotherms plotted for individual adsorbents are shown in Figure 1 to 10. The comparison of isotherm is shown in figure 11 and 12. Among the two types of isotherms Freundlich isotherm is fitting well to the experimental results. Freundlich isotherm is for heterogeneous surface and exponential distribution of energy and sites on the surface. Phenol adsorption on activated carbon is exothermic adsorption so it is obvious that every site of the surface will be of different energy.

IV. CONCLUSIONS

All the adsorbent were compared. The maximum performance was shown by activated carbon and then it was followed by T- bentonite, saw dust carbon, fly ash and at last Natural bentonite. The maximum phenol percentage removed by activated carbon found was 97.24%. Similarly for T- bentonite – 82.66% saw dust carbon - 74.50%, fly ash –70.10 % and Na-bentonite – 49.21% which is lesser than all other adsorbents. So it is concluded that

% phenol removal using Na-B can be expanded only after physical and chemical treatment. Fly ash and saw dust are one form of waste coming from industries; they can be again reused as an adsorbent for such waste water streams after a few treatments. The activated carbon is best for effective removal however because of its loss all through regeneration 15-20% and price is ready excessive in comparison with different adsorbents. Equilibrium facts have been derived for all six adsorbents. The equilibrium facts were suited to isotherms like Freundlich isotherm and Langmuir isotherm. Out of these two isotherms, Freundlich found well fitted to the data.

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