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Mechanism and Kinetics of Reduction of Cr(VI) by D-glucose in Aqueous Phase

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Abstract-

The objective of this work was to investigate the reaction stoichiometry, kinetics and mechanism for Cr(VI) reduction by D-glucose in the aqueous phase. Experimental reduction rates were determined for different values of the process parameters such as the mole ratio of the reactants, pH, temperature as well as the initial Cr(VI) concentration. Nearly 60% reduction of Cr(VI) has been achieved after 1hr with stoichiometric amount of glucose. Almost complete reduction could be achieved by using 50% excess glucose. The effective reduction of Cr(VI) by D-glucose suggests that this is a potentially useful technique for reduction of Cr(VI) for ex-situ remediation of Cr-contaminated soil.

I. INTRODUCTION

Chromium is widely used in a variety of industrial processes such as metal electroplating, leather tanning and manufacture of products for corrosion protection. Soil contamination because of illegal dumping of wastes from above industries has been found in many countries including India [1, 2]. Remediation of Cr(VI)-contaminated soil may be done by using an effective reducing agent in-situ or by extracting it by soil washing followed by ex-situ reduction in the aqueous phase by reagents such as Various reducing agents such as sulfides, nanoscale Zero-valent Iron (ZVI), hydrazine, glucose etc [3]. Studies of the reduction rate and development of rate equation are important for design of systems for ex-situ reduction of aqueous Cr(VI) extract. Glucose has been used commercially for this purpose, but basic rate data are not available in the literature.

II. MATERIALS & METHODS

Cr(VI) stock solutions were prepared by dissolving a weighted amount of dried $K_2Cr_2O_7$ in Milli-Q deionized water. Analytical reagent grade (Merck Life Science) D-glucose solution at requisite concentration was also prepared for the experiments. Experiments were started after mixing the Cr(VI) and glucose solutions at a certain ratio in a beaker kept homogeneous by a magnetic stirrer. The pH of the solution was adjusted by addition of a few drops of .2(M) H_2SO_4. Samples were drawn from time to time filtered through a PTFE syringe filter and analyzed for the remaining Cr(VI) by 1,5-diphenyl carbazide (DPC) spectrophotometric technique at 540 nm.

Several sets of experiments were conducted to investigate the effects of various process parameters on the rate of Cr (VI) reduction. The initial concentrations of Cr(VI) were set at 6000, 5000, 4000 and 3000 mg/l. To study the effect of molar ratios of Cr (VI) to glucose, the molar ratios were set at 1:1, 1:1.5, 1:2.5. The pH values of solutions were taken as 2.236, 3.146, 4.39 and 4.45 and the temperature was fixed 30, 40 and 45^{o}C.

III RESULTS & DISCUSSION

3.1 Effect of molar ratios of Cr(VI) to glucose on the reduction of Cr(VI)

Effect of molar ratios of Cr(VI) to glucose is shown in Fig.1. Increased molar ratio predictably enhanced the rate and extent of reduction. The stoichiometric mole ratio of the reactants is

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1.5 and this parameter as well as the pH of the reaction medium has significant influence of reduction of Cr(VI). Nearly 63.95 % Cr (VI) was reduced when the molar ratio was set at 1:2.5 over a reaction time of 1 hour, but only 56.4% was reduced when a molar ratio of 1:1 was used. The reduction rate is also much faster at a higher mole ratio of the reactants (Fig. 2).

The solution pH also has considerable effect of the reduction rate. The lowest pH used is 2.2. A lesser pH would surely enhance the reaction but will not be practically relevant.

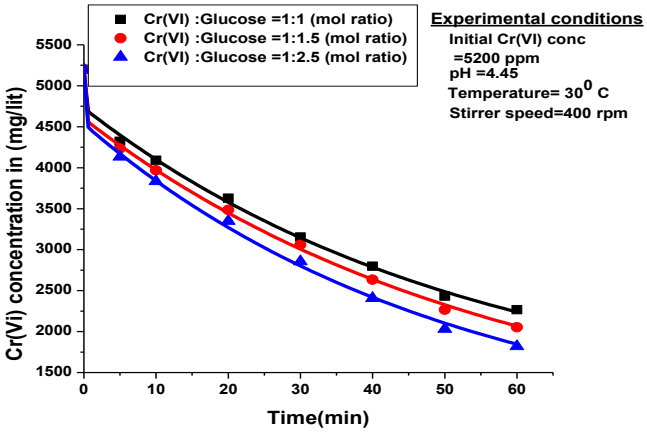

Fig. 1. Effect of molar ratios of Cr (VI) to glucose on the reduction of Cr (VI) at pH 4.45.

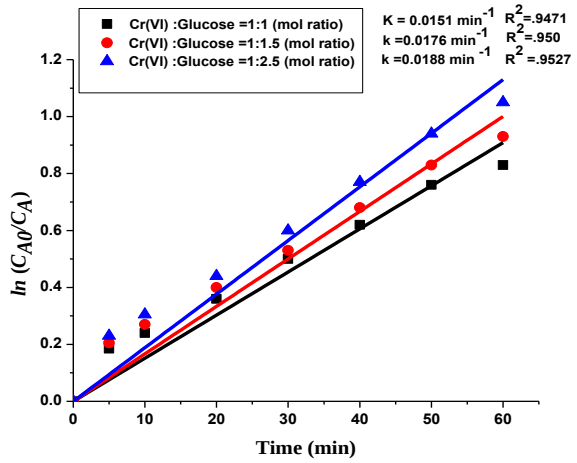

Fig. 2. Plot of ln (C_{Ao} / C_A) vs. time at different molar ratios of Cr (VI) to glucose at pH 4.45

3.2 Effect of pH on the Cr(VI) reduction of Cr (VI)

The effect of initial pH on the reduction of Cr (VI) using glucose was investigated by changing initial pH of glucose +Cr (VI) solution from 2.236 to 4.45 and keeping other experimental conditions constant. The results are shown in Fig.3.

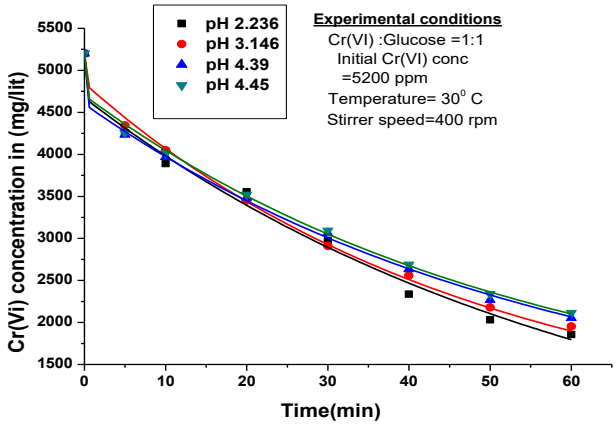

Fig. 3 Effect of pH on the reduction of Cr (VI)

IV. CONCLUSION

In the present work, Glucose is tested as a reducing agent for the Cr(VI) reduction in wastewater and also studied the effects of initial Cr(VI) concentration, molar ratio of Cr(VI) to glucose, pH and temperature on the Cr(VI) reduction.

The results showed that Cr (VI) was reduced by glucose effectively by increasing Cr(VI) to glucose mole ratio. Nearly 63.95% and 59.35% of Cr(VI) was reduce in 60min at 1:2.5 & 1:1.5 mole ratio at pH 4.45. Effect of temperature and pH was not so much as compared to mole ratio. It is clear from the results that complete reduction is achievable within a reasonable time with some excess glucose even at a very mild pH of 4.45

ACKNOWLEDGMENT

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