

# Adsorption Study of Co(II) by EDTA-Functionalized Nanoporous Silica

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## 1. Introduction

Activation products like  $^{60}\text{Co}$ ,  $^{58}\text{Co}$  along with  $^{59}\text{Fe}$  and  $^{54}\text{Mn}$  mainly produced by activation of corrosion products by neutron flux in the reactor coolant. The corrosion products are released into primary nuclear reactor water due to wear and tear of mechanical parts of system. In contrast to  $^{58}\text{Co}$ ,  $^{59}\text{Fe}$ , and  $^{54}\text{Mn}$ ,  $^{60}\text{Co}$  is a major long-term source of radiation in pressurized water reactor (PWR) and boiling water reactor (BWR) plants due to its high gamma energies ( $E_\gamma$ : 1.17 MeV and 1.33 MeV) and relatively long half-life (5.23 yrs).  $^{60}\text{Co}$  generates major radiation field problems and poses hindrance at maintenance work. In addition, it can be transported throughout the system in either soluble forms or insoluble crud [1]. Moreover, in ionic form as  $\text{Co}^{2+}$ , it has tendency to replace  $\text{Fe}^{2+}$  and  $\text{Ni}^{2+}$  species by combining with inner and outer oxide layers usually formed in reactor coolant systems. Therefore, removal of radioactive and non-radioactive cobalt from reactor coolant has always been a challenge to researchers.

The prime focus of this research was to investigate the use of EDTA-SBA-15 for rapid and effective removal of cobalt in order to reduce the secondary nuclear waste volume generated during decontamination. Moreover, the behavior of adsorbent at different solution conditions such as strong acidic, high temperature, concentrated solutions, and in mixture with other corrosion metal ions was also studied.

## 2. Results and Discussion

### 2.1 Adsorption studies

Stability of adsorbent and adsorbent-metal complex is associated with pH. Therefore, cobalt uptake was studied by mixing SBA-15 and EDTA-SBA-15 in cobalt chloride solution at fixed and non-fixed

equilibrium pH, as can be seen in Fig. 1. It can be observed that cobalt showed no affinity with SBA-15 at all pH range but one of the best adsorption capacities (1.40 mmol/g) was achieved by EDTA-SBA-15. This indicates perfect loading and stability of functional group over acidic pH range.

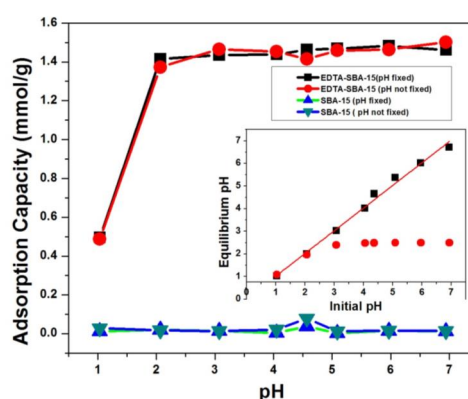


Fig. 1. Effect of pH on adsorption capacity (inset graph shows change in equilibrium pH of EDTA-SBA-15 with respect to initial pH) ( $C_0=2\text{mmol/L}$ , S:L ratio 1g/L contact time 2hr, 150RPM, at RT).

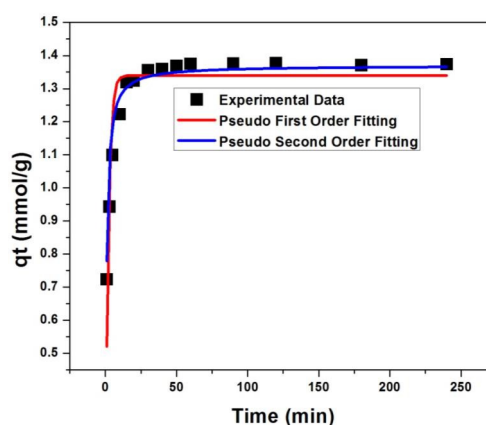


Fig. 2. Adsorption kinetics of Co(II) on EDTA-SBA-15 ( $C_0=2\text{mmol/L}$ , pH2.5, RPM 150, at RT).

Pseudo Second Order (PSO) rate law best fits to the experimental data for all points as can be seen in Fig. 2 and equilibrium adsorption capacity has been achieved in first 20 min which shows fast kinetics. Furthermore, It can be seen in Table 1 that EDTA-SBA-15 posed best  $q_e$  (1.40 mmol/g) value as compared to other EDTA based adsorbents.

Table 1. Comparison with various EDTA based adsorbents used for Cobalt removal

Functionalized matrices	pH	$q_{\max}$ (mmol/g)	Reference
Silica	1.0	$\approx 0.01$	[2]
	3.1	0.34	[2]
Gel	3.0	0.30	[3]
	2.1	1.07	[4]
Chitosan	2.1	1.07	[4]
	3.0	0.46	[5]
Composite	3.0	0.47	[5]
	3.0	0.47	[5]
Maize Cob	7.5	0.87	[6]
Carbon	-	0.80	[7]
	-	0.80	[7]
SBA-15	2.0	0.17	[8]
SBA-15	2.5	$\approx 1.40$	This study

### 3. Conclusions

The synthesized adsorbent showed best adsorption capacity (1.40 mmol/g) for Co(II) ions as compared to other EDTA based adsorbents. Kinetic equilibrium in case of cobalt can be reached within 20 min. The adsorbent can be used in both strong acidic and neutral conditions, and it is stable at moderate temperature and mixed ionic media. In case of mixed ionic media of Co(II), Cu(II), and Ni(II), the adsorbent showed higher selectivity for Ni(II), as compared to other metal ions.

### 4. REFERENCES

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