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## REVIEW

# Adsorption of some heavy metal ions by used different immobilized substances on silica gel

Mohamed M. Shahata

*Environmental affairs Department, Assiut University Hospitals, Assiut University, Assiut, Egypt*

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## KEYWORDS

Poly(8-hydroxyquinoline);  
Immobilization;  
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Cu(II);  
Fe(III)

**Abstract** 8-Hydroxyquinoline, HQ, or poly(8-hydroxyquinoline), PHQ, was immobilized on the activated silica gel for extractive concentration of metal ions. FTIR was used to prove the result caused by the immobilization of PHQ on the surface of functionalized silica gel. The thermal gravimetric analysis (TGA) and differential thermal analysis (DTA) prove that Si–PHQ–Cu is more highly thermally stable and strongly adsorbed water than Si–PHQ. Spectra of the solution produced from substrate of PHQ immobilized on silica gel showed record peak at 305 nm which was maximized at pH  $7.2 \pm 0.1$  of the universal buffer solution. By the addition of Cu(II) ion solution, a peak at 380 nm was appeared corresponding to formation of HQ–Cu(II) coordinated complex.

Spectra of 100 mg of substrate (Si–HQ, Si–PHQ, or Si–Cu) at pH  $7.2 \pm 0.1$  universal buffer solution was recorded, solutions of metal ions were added, after contact time, filtrate, dissolve the solid precipitate in pure ethanol and record the spectra of this solution. A peak at 380 nm appeared corresponding to HQ–Cu(II) complex. The capacity of Si–HQ for extraction of Cu(II) ion was 10 mmol/g. Immobilization of Cu(II) metal ion on silica gel (Si–Cu) was studied. The maximum amount of HQ that can be extracted was 7 mmol/g. In the case of Fe(III) ion on Si–HQ, new two peaks appeared at 580 and 455 nm. The capacity of Si–HQ for extraction of Fe(III) ion was 20 mmol/g.

Addition of Cu(II) on Si–PHQ, a new peak at 380 nm was appeared corresponding to PHQ–Cu(II) coordinated complex. The capacity of Si–PHQ for extraction of Cu(II) ion was 40 mmol/g. While, Si–Cu can extract PHQ, the maximum amount of PHQ that can be extracted was 20 mmol/g. Spectra of

E-mail address: [mohamedshahata67@hotmail.com](mailto:mohamedshahata67@hotmail.com)

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Fe(III) ion on Si-PHQ was recorded, new two peaks were appeared at 580 and 455 nm corresponding to the formation of PHQ-Fe(III). The capacity of Si-PHQ for extraction of Fe(III) ion was 40 mmol/g. PHQ immobilized on silica gel was useful for removal of Iron from the sytron syrup (anti-anemic).

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## 1. Introduction

Hydroxyquinoline is a well-characterized organic chelating ligand, which can form covalent compounds with over 60 metal ions under controlled pH conditions, and its preference for transition and heavy metal cations over alkaline earth cations are well known (Rao and Gladis, 2002). 8-Hydroxyquinoline, 8HQ, and its derivatives as well as related metal complexes are playing a uniquely important role in different disciplines of chemical research and applications. 8HQ, as a complex one or as sequestering reagent, is considered second to EDTA and its analogues in binding with metal ions (Soroka et al., 1967). 8HQ was mainly applied for analytical purposes and separation techniques as an excellent reagent for the extraction of metal ions due to its extraordinary coordinating capabilities (Hollingshead, 1954; Mahmoud, 2006; Mahmoud and Soliman, 2003; Wen and Shan, 2002; Goswami et al., 2003; Firdaus et al., 2007). However, in coordination chemistry, versatile synthetic approaches for the formation of metal complexes of 8HQ and its derivatives were extensively used to open a wide range of di and tri-valent metal complexes that can be used as an arsenal for various impacts and applications in different fields.

Ahmed et al. (2003), have prepared spectro analytical solutions and using several spectroscopic techniques, characterized coordination polymer based on poly(8-hydroxyquinoline) complexed to some metal ions. The lowest potential energy and dipole moment of the optimally proposed structure of PHQ that is coordinated to copper ion were estimated by Molecular Mechanics (MM+) calculations.

Silica gel is a porous, granular form of silica, synthetically manufactured from sodium silicate or silicon tetrachloride or substituted chlorosilane or the silicate solution. Silica gel

synthesis from sodium silicate solution is well documented by (Iler, 1979). Silica particles of small particle size (2–5 nm) have an extraordinarily large surface-to-volume ratio ( $\sim 2 \times 10^9 \text{ m}^{-1}$ ) and a corresponding high specific surface area ( $\sim 900 \text{ m}^2/\text{g}$ ). It is not surprising, therefore, to note that the chemistry of the interior surface of silica gel plays a dominant role in its chemical and physical behavior (El-Nahhal and El-Ashgar, 2007). Silica can be regarded as a polymer of silicic acid, consisting of inter-linked  $\text{SiO}_4$  tetrahedral. The structure terminates at the surface in either a siloxane group ( $=\text{Si}-\text{O}-\text{Si}=\text{}$ ) with the oxygen on the surface, or one of several forms of silanol groups ( $=\text{Si}-\text{OH}$ ). The silanols can be divided into isolated groups (or free silanols), where the surface silicon atom has three bonds in the bulk structure and the fourth bond is attached to a single OH group, and vicinal silanols (or bridged silanols), where two single silanol groups, attached to different silicon atoms, are close enough to the hydrogen bond. The third type of silanols, geminal silanols, consists of two hydroxyl groups that are attached to one silicon atom and that are too close to form hydrogen bond between each other (Kiselev and Lygin, 1975). The enhanced acidity of the silica surface gives it a high degree of chemical reactivity, so it can react with many coupling agents to immobilize organo-functionalized silanes (Leyden and Luttrell, 1975), in which Lisickin's team and Zaitsev have made an important contribution (Lisickin et al., 2003; Zaitsev, 1997).

Surface modification of silica relates to all the processes that lead to change in chemical composition of the surface. Surface can be modified either by *physical treatment* (thermal or hydrothermal) that leads to change in ratio of silanol and siloxane concentration of the silica surface or by *chemical treatment* that leads to change in chemical characteristics of the silica surface. By the modification the adsorption properties are significantly

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