CHARACTERISATION OF ACTIVATED CARBON USED FOR GOLD ADSORPTION

By

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Master of Engineering

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Declaration

I declare that this thesis is my own, unaided work, except where specific acknowledgement is made. It is being submitted for the Degree of Master of Engineering to the Faculty of Engineering, University of Pretoria, Pretoria. It has not been submitted before for any degree or examination to any other university.

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December 1999
Characterization of activated carbon used for gold adsorption

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The adsorption of gold cyanide onto activated carbon is controlled by the pH and the presence of other ions in the solution. The adsorption increases with an increase in pH. The adsorption can be controlled by the addition of specific ions. The surface area of the activated carbon is also important in determining the adsorption efficiency. The adsorption of gold cyanide onto activated carbon is affected by the pH and the presence of other ions in the solution.

To my fiancée Blandine Makwanza and my brother Eric Makwala for their love and encouragement.

The gold adsorption activity of activated carbon was measured as a function of the chemical and physical properties of the carbon. Heat treatment of activated carbon in the presence of nitrogen gas produced surfaces that increased the adsorption of gold cyanide compared to the standard carbon. The effect of the pH of the activated carbon showed an increase with heat treatment indicating a change in surface chemistry of the activated carbon. However, no drastic change in the adsorption
Abstract

Characterisation of activated carbon used for gold adsorption

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The surface of activated carbon contains acidic and basic surface groups which influence the adsorption of gold di-cyanide from the aqueous solution. A surface charge density arises from ionisation of these surface groups in response to the solution pH and ionic strength. The surface of an activated carbon made from coconut shell was characterised by potentiometric titration. The point of zero charge, pH where the surface charge shifts from positive to negative, has been found to change with the time allowed between subsequent additions of the titrant and with the pre-treatment of the activated carbon. When submitted to slow titration, the activated carbon shows a neutral or acidic point of zero charge. However, slow titration leads to a point of zero charge that shifts towards more alkaline values. The surface potential calculated from the Gouy-Chapman relationship between the surface charge and the surface potential does not reflect a realistic picture of the potential distribution inside the carbon particle. The size of the micropore is too small to allow such a potential distribution from the pore walls. The Donnan potential has been introduced, because it takes into account the overlapping of the potential inside a highly porous adsorbent. However, more work has to be done on the way the Donnan potential should be evaluated for an activated carbon.

The gold adsorption activity of activated carbon was measured as a function of the chemical and physical properties of the carbon. Heat treatment of activated carbon in the presence of nitrogen gas produced surfaces that increased the adsorption of gold di-cyanide compared to the standard carbon. The immersion pH of the activated carbon showed an increase with heat treatment indicating a change in surface chemistry of the activated carbon. However, no drastic change in the pore volume
distribution was observed after heat treatment of the activated carbon. It was shown that micropore volume contributes to the adsorption of gold di-cyanide. The combined effect of textural properties and basicity of the activated carbon is relevant for the adsorption of gold di-cyanide.

**Keywords** - Gold di-cyanide, activated carbon, adsorption, potentiometric titration, surface chemistry, and gold adsorption activity.

**Opsomming**

_Eienskappe van gek activeerde koolstof vir die gebruik van goud adsorpsie_

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Die oppervlak van geactiveerde koolstof bevat suur- en basisoppervlakgroep wat die adsorpsie van goud disianied vanuit die waterige oplossing beïnvloed. 'n Oppervlakladingdigtheid vorm as gevolg van die ionisasie van hierdie oppervlakgroep. Die pH van die oplossing en ioniese sterkte beïnvloed die ionisasie. Die oppervlak van geactiveerde koolstof, verkry van 'n kokosneutdop, is gekarakteriseer deur potensiometriese titrasie. Daar is gevind dat die punt van nullading, die pH waar die lading op die oppervlak van positief na negatief verwissel, verskuif met die grootte van die tydensuur tussen opeenvolgende titraattoevoegings en vooraf-behandeling van die koolstof. Die geactiveerde koolstof toon 'n neutrale of suur nul-ladingpunt tydens stadige titrasie. Stadige titrasie lei egter tot 'n nul-ladingpunt wat neig na alkaliese waardes. Die oppervlakpotensiaal, bereken uit die Gouy-Chapmanverwantskap tussen oppervlaklading en potensiaal, gee nie 'n realistiese beeld van die potensiaal-verspreiding binne die koolstofpartikel nie. Die grootte van die mikropore is te klein om so 'n potensiaalverspreiding vanaf die poorwande toe te laat. Die Donnanpotensiaal is gebruik omdat dit die oorlewing van potensiaal binne in 'n hoogs poreuse adsorbeerder inageneem. Meer werk moet
egter nog gedoen word op die wyse waarop die Donnanpotensiaal vir geaktiveerde koolstof geëvalueer kan word.

Die goudadsorbsie-aktiwiteit van geaktiveerde koolstof is gemeet as 'n funksie van die chemiese en fisiese eienskappe van die koolstof. Oppervlakte wat meer gouddisianied as die standaard koolstof adsorbeer is verkry deur die hittebehandeling van geaktiveerde koolstof in die teenwoordigheid van stikstofgas. Die onderdompelings-pH van die geaktiveerde koolstof neem toe met hittebehandeling, wat toon dat 'n verandering in oppervlakchemie van die geaktiveerde koolstof voorkom. Geen dramatiese verandering in poervolume-verspreiding na hittebehandeling van die geaktiveerde koolstof is egter waargeneem nie. Dit is getoon dat die mikropoorvolume bydra tot die adsorbsie van gouddisianied. Die gekombineerde effek van tekstuureienskappe en basisiteit van die geaktiveerde koolstof is van belang vir die adsorbsie van gouddisianied.

**Sleutelwoorde**-Gouddisianied, geaktiveerde koolstof, adsorpsie, potensiometriesie titerasie, oppervlakchemie, goudadsorpsie-aktiwiteit.

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Contents

Declaration i
Abstract iii
Opsomming iv
Acknowledgements vi
Contents vii

1 Introduction 1

2 Adsorption of Gold Di-Cyanide onto Activated Carbon 4
   2.1 Introduction 4
   2.2 Activated carbon 4
   2.3 Equilibrium adsorption of gold di-cyanide onto activated carbon 7
   2.4 Factors affecting the equilibrium adsorption of gold cyanide 8
   2.5 Kinetic mechanism of adsorption of gold di-cyanide onto activated carbon 13
   2.6 Modelling of the equilibrium adsorption of gold di-cyanide onto activated carbon 14

3 Surface Complexation Theory 17
   3.1 Introduction 17
   3.2 Theory of the surface complexation model 18
   3.3 Surface ionisation and complexation at the activated carbon/water interface 25
   3.4 Phenomenological adsorption equilibrium models 27
   3.5 Porosity and double layer of activated carbon 29
   3.6 Conclusion 31

4 Surface Titration of Activated Carbon 33
   4.1 Introduction 33
   4.2 Point of zero charge and isoelectric point of non porous adsorbents 34
   4.3 Point of zero charge and isoelectric point of activated carbon 35