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EcoBalance2010
The 9th International Conference on EcoBalance
November 9-12, 2010, Tokyo, Japan

P-001

Eco-vision Aspect and Sustainable Development through Hydrogen Economy in South Africa

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Abstract

Hydrogen is a relevant purpose that South Africa sets as priority of renewable technologies in a bid to reduce the country's oil and gas dependence and consequently reduction of its heavily carbon emission. Possessor worldwide of almost 75% of the platinum, South Africa sees the opportunity to play a new role in decades coming with the development of hydrogen economy highlighting positive impacts in socio-economical and ecological aspects. Platinum is a best catalyst metal to be used as electrode to the production of hydrogen by water electrolysis with no carbon emission. This paper examines the sustainability and technological development of hydrogen production for fuel cells technologies processes, the input-output energy comparison involved by utilizing life cycle inventories in which the energy and raw material consumption and different types of emissions related to a specific product are measured, analyzed and summoned over the life cycle's entire products from an environmental viewpoint.

Keywords: Hydrogen, electrolysis, Platinum nanophase electro catalysts composites electrodes, Life Cycle Inventories.

1. Introduction

The entire and complete project of hydrogen economy is technologically based on the elaboration and production of main components among which the development of platinum electrodes, development of membranes insulators and conductors of different electro kinetic particles such as electron and proton, development of electrolysis environment, production of hydrogen gas by water electrolysis, storage medium and fuel cells. This work was focused on the development of life cycle inventories of the platinum nanophase electro catalysts composites electrode process resulted from the experiment developed in South Africa [3]. The basic initiative for the experimentation had invested on the assumption stating that if high current densities could be obtained for a low energy input and particularly with low electrolyte environments using renewable energy with a strong emphasis upon waste reduction and reuse among environmental impacts as well as the use of platinum electro catalyst nanophase integrated into composite electrodes, it could result a commercialization potential [3].

Besides, Umberto 5.5 consult version software was used to develop flows charts, Input-output and Life cycle Inventories balance sheets respectively for both Hexagonal Mesoporous Silica (HMS) material and the platinum nanophase electro catalysts composites electrode. Platinum nanophase was supported upon the mesoporous HMS by incipient wetness impregnation. The HMS is not commercially available and the synthesis was obtained according to standard methods done by Tanev and Pinnavaia described by Kwang [2].

2. Objective

The aim of this work was inspired from the purpose of the conference to use Life Cycle Inventories and Assessment tools to analyze processes developed with new technologies with a focus on environmental impacts and effective benefit on the energy as well.

3. Scope

The study was limited for modeling Input-Output and Life Cycle Inventories flow charts and balance sheets respectively for the HMS material synthesis and the platinum nanophase electro catalysts composites electrode synthesis, obtained from experiment processes.

4. Results and discussion

4.1 Balance sheets

Table 1: Hexagonal Mesoporous Silica. Balance sheet Preview from Umberto.

Balance sheet Preview		
Project : Hexa Mesoporous Silica (HMS)		
Scenario : HMS production		
Net : Main		
Section : Input/output		
Group : Material		
Input		
Item	**Quantity**	**Unit**
G 1-Dodecylamine (C12H27N)	0.0100	Kg
G Deionized water	0.8000	Kg
G Electricity	17314998.0672	KJ
G Electricity (En. to stir)	142560.0000	KJ
G Ethanol (EtOH)	0.1050	Kg
G TEOS (Si(OC2H5)4)	0.4460	Kg
G Water (H2O)	0.1067	Kg
Sum	**Quantity**	**Unit**
KJ	**17457558.0672**	KJ
Kg	**1.4677**	Kg
Output		
Item	**Quantity**	**Unit**
G Ethanol (EtOH)	0.5000	Kg
B Gas emission	0.0099	Kg
G HMS	0.0901	Kg
B Wastewater	0.8677	Kg
Sum	**Quantity**	**Unit**
Kg	**1.4677**	Kg

Table 2: Platinum nanophase electro catalyst HMS impregnated. Balance sheet Preview from Umberto.

Balance sheet Preview		
Project : Platinum nanophase synthesis		
Scenario : Pt nanophase HMS impregnated		
Net : Main		
Section : Life Cycle Invetories		
Group : Material		
Reference Flow: Pt-HMS heated (Output, A31)		
Quantity : 0.02577 Kg		
Input		
Item	**Quantity**	**Unit**
G Deionized water	0.016674	Kg
G Electricity	7557655.705885	KJ
G Formaldehyde	0.001458	KJ
G HMS	0.001375	Kg
G Methanol	0.000742	Kg
G Methanol/formaldehyde sln	0.006000	Kg
G PtCl6.6H2O	0.001296	Kg
Sum	**Quantity**	**Unit**
KJ	**17457558.705885**	KJ
Kg	**0.027545**	Kg
Output		
Item	**Quantity**	**Unit**
B Formaldehyde toxic emission	1.37651	Kg
B Heat emitted	1513363.43896	Kg
B Methane toxic-emission	1.37565 E-6	Kg
B Methanol/Formaldehyde citotoxicity	0.00171	Kg
G Pt-HMS heated	0.02577	Kg
B Pt-HMS solid waste	6 E-5	Kg
Sum	**Quantity**	**Unit**
KJ	**1513363.43896**	
Kg	**0.02754**	Kg

4.2 Flow charts

4.2.1 Preparation of Hexagonal Mesoporous Silica (HMS)

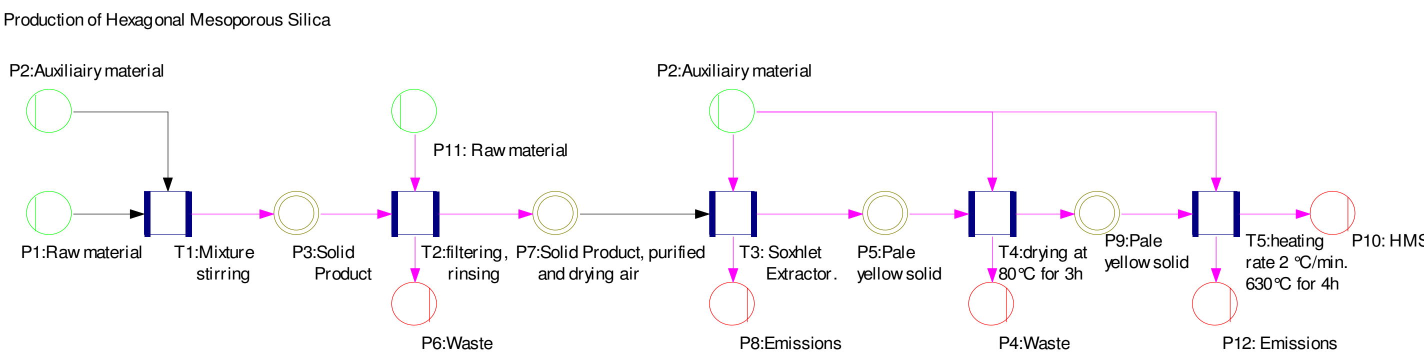

Fig.1 Flow charts for the elaboration of HMS.

4.2.2 Preparation of HMS-Platinum nanophase electro catalysts composite electrode

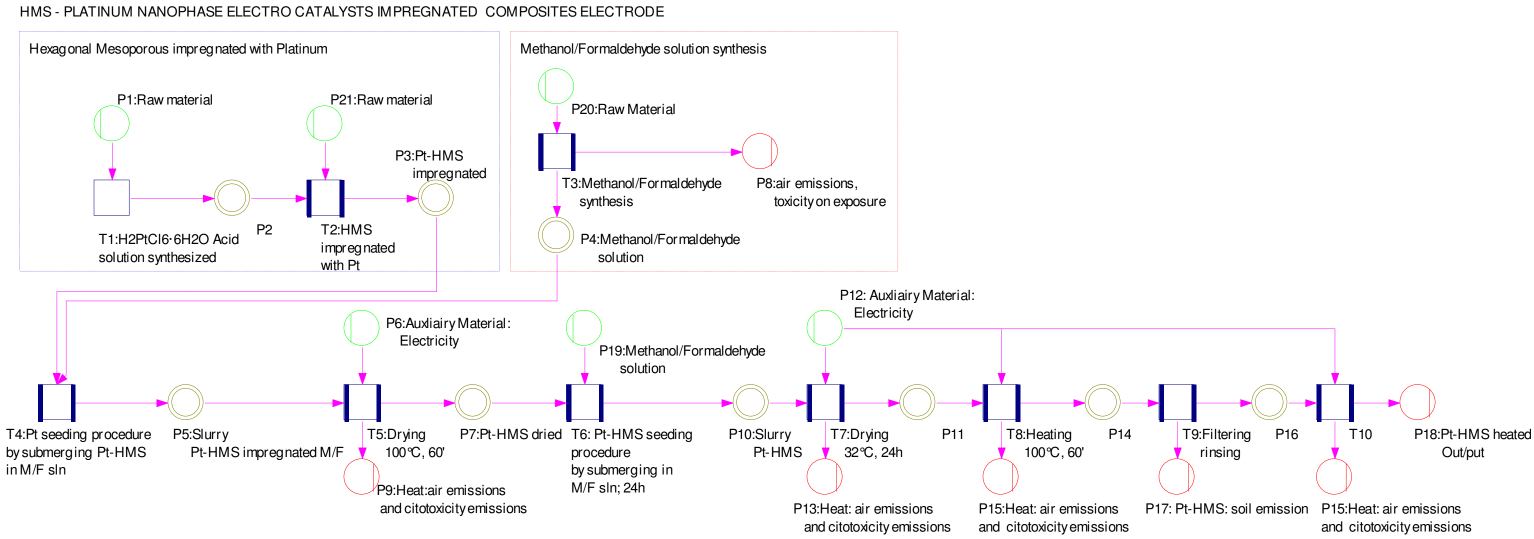

Fig.1 Flow charts for the elaboration of Pt-HMS impregnated.

5. Interpretation of results

On basis of experiments, developed flow charts were established through Umberto 5.5. – In which were described processes and quantified data. Sources such as internet, chemistry and physics published articles were used to determine different type of emissions in accordance with chemical reactions applied. Stored modules predefined in the software database library, where modules of materials have been predefined with their respective types of emissions, were not utilized for most of the materials were not therein found. The waste of electric energy as heat emitted and toxic emissions from formaldehyde and methane were observed. Major environmental impacts were not noticed.

The input-output energy comparison was assessed with reference to the result from the experiment thence was established as follow the incorporating supported platinum nanophase electro catalysts in composite electrodes resulted in production of electrodes capable of current densities for hydrogen production by water electrolysis of about $600 mAcm^{-2}$ at 60 ◦C at an applied potential of 2V in a high electrolyte environment and most, the fact that the electrodes were able to withstand the very high degree of hydrogen gas evolution at an applied potential of 6V showed that even under these aggressively accelerated testing conditions the nanophase catalyst containing thin films were stable and durable [3].

6. Conclusion

As known, the hydrogen gas for the purpose to fuel cells development stands for no carbon emission. On the other hand the upstream development composites tools for hydrogen production with electrolysis of water such as electrodes and specially for this experiment with the platinum nanophase electro catalysts electrodes composite had to be investigated whether it offers pollution emissions and in which proportion. The analysis was assessed with the use of Life Cycle Inventories tools. Furthermore, the effective benefit of the energy in the hydrogen gas production with platinum nanophase electro catalyst composite electrode was investigated with success by the application in a high electrolyte environment.

7. References

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