Oriental Journal of Chemistry Vol. **26**(3), 1131-1134 (2010)

Study on nitrogenous fertilizer industry spent catalyst as substitutes materials for production of hydrogen by steam-iron process

R.P. PRAJAPATI[1]*, ANAND SHARMA[2] and D.R. TIWARI[3]

[1]Department of Chemistry (DESM) Regional Institute of Education (NCERT), Bhopal - 462 013 (India).
[2]Department of Chemistry & [3]Department of Geology, Government MVM, Bhopal - 462 001 (India).

(Received: June 20, 2010; Accepted: August 12, 2010)

ABSTRACT

Nitrogenous fertilizer industry generated so many spent catalysts during the manufacturing of fertilzers. Catalysts used in the fertilizers production process need to disposal off after their activities are significantly reduced. Disposal of spent catalyst is a problem as it falls under the category of hazardous industrial waste. So many chemical industries, manufacturing products like vegetable oils, pharmaceutical products, fertilizer, paints and pigments etc., are require a cheaper source of pure hydrogen. The demand for hydrogen is likely to go up a thousand fold, when the world's fossil fuel stock will be exhausted and technology must turn to hydrogen to be used as fuel. For the production of sufficient quantities of hydrogen of the requisite purity, the antique steam-iron process still remains one of the most attractions from various indigenous source of iron oxide as substitute materials for hydrogen production. Activity and production behaviour of catalyst was observed by magnetic data which indicated that sintered haematite and spent ammonia catalyst are unsuitable for production of hydrogen, but gives better yield of hydrogen.

Key words: Nitrogenous fertilizer, Catalyst, steam-iron process.

INTRODUCTION

Solid waste coming out from nitrogenous fertilizer industries are principally spent catalysts which that generated in ammonia production. Catalyst used in various processes has different useful lives ranging from 5 to 7 year's. The reuse of spent catalysts for recovery of metal and as again catalysts is an important economic aspect, as most of these catalysts are supported, usually on allumina/silica, with varing percent of metal, concentration metals like Fe, Mo, Co, Zn, Ni, Cr, etc., are widely used as a catalyst in nitrogenous fertilizer industries.The production of hydrogen by steam iron process using, Indian siderite, sintered haematite and spent ammonia catalyst are depends on their activity. The economic value of the process is related to the value of the prdoucts. Thus the product selectivity and the overall efficiency of the process are the main parameters of any gas converting design. In industrial scale, the gas products are separated from the desired products and after the condensation of water vapour, a part of this gas is recycled to the reactor in order to increase the efficiency of the process. The studies are confined to the use of various iron oxides catalysts in steam iron process for production of pure hydrogen. The studied on the comparative cost of hydrogen production furnised by several workers, indicates that hydrogen production by steam iron process will be cheaper than even naphtha reformation process. The present study is under taken to comparative catalytic behaviour of Indian siderites sintered haematite and spent catalyst activity for production of hydrogen.

MATERIAL AND METHODS

In the present work, the samples were collected and analyzed for their activity and physico-chemical parameter's as production of hydrogen using (1) Indian siderites (A_1) (2) Sintered haematite (B_2) (3) Spent ammonia catalyst (C_3). Sample C_3 was collected from NFL Vijaipur unit, district Guna (M.P.). Collected samples were studied for production of hydrogen using steam iron process as per standard method (WGSR). Sample of different catalysts crushed and dispersed on alluminia. Activity performance of collected samples were measured by the conventional (BET) method[1]. Magnetic susceptibility of collected samples were analysed by magnetic balance using GOUY apparatus[2] at room temperature. The chemical composition of different sample used in analysis are given in Table -1 and chemical reaction is shown as below:-

Chemical reaction

$$C_{(s)} + H_2O_{(g)} \rightarrow CO_{(g)} + H_{2(g)}$$

$$350^oC$$

$$CO_{(g)} + H_2O \rightarrow CO_{2(g)} + H_{2(g)}$$

It reaction catalyzed by solid iron oxide (Spent catalyst) at about 350°C. The above reaction is the water gas shift reaction (WGSR) known as steam reforming.

RESULTS AND DISCUSSION

The various properties of three catalyst are reported in table -2 & 3. These data are discusses in the same order as presented in the table.

The data table revealed that initial hydrogen production was found much better in Indian siderite (A_1) than sintered haematite and spent catalysts. Therefore it is observed that in spent catalyst, porosity of iron and surface area are decreased and density is increased. Magnetic susceptibility and magnetic moment of the spent catalyst also lower than the fresh catalyst, due to this reasion catalytic behaviour of spent catalyst is lower than to fresh catalyst. Because of spent catalyst are already used in fertilizer industry but it has economical value for production of hydrogen. So that disposed spent catalyst from industry useful for production of hydrogen and other purpose.

Table 1: Chemical composition of used catalysts

S. No	Composition	Indian Siderite A_1	Sintered Haematite B_2	Spent Catalyst C_3
1.	Total Fe	41.09	68.7	80.40
2.	SiO_2	4.32	2.18	0.74
3.	Al_2O_3	5.12	1.5	2.55
4.	CaO	0.12	-	3.01
5.	MgO	0.18	-	-
6.	TiO_2	0.31	-	-
7.	MnO	0.30	-	-
8.	P_2O_5	0.27	-	-
9.	SO_3	0.25	-	-
10.	CO_2	27.5	-	-

Table 2: Observed physico chemical properties of fresh and spent ammonia caalyst

S. No.	Catalyst	Activity	Magnetic susceptibility in C.G.S. units × 10^{-6}
1.	A_1	65	+ 6.69
2.	B_2	60	+ 4.78
3.	C_3	48	+ 3.81

Table 3: Charging details and initial activity data of different samples

S. No.	Details	Indian Siderite A_1	Sintered haematite B_2	Spent catalyst C_3
1.	Volume of sample mass	50.0	50.0	50.0
2.	Weight of the sample	94.0	105.0	119.0
3	Total Fe %	41.09	68.7	80.40
4.	Weight of Fe present in the charged samples	38.54	72.13	95.7
5.	Initial H_2 production in litres	16.8	24.7	26.7
6.	Time consumed in initial hydrogen production	18.0	25.7	20.0
7.	Rate of H_2 production litre / hour	56.0	59.28	80.1
8.	Hydrogen produced/ 100 gm (litre)	17.8	23.5	22.43
9.	Hydrogen produced per 100 gm. of Fe in the sample.	43.3	34.2	27.9

CONCLUSION

From the results and observation of the present investigation, it follows that the different types of catalyst before and after used (spent catalyst) in industries have more difference in catalytic behaviour according to observation data. Initial parameter's indicated that the discharged catalyst from industies contained lower catalytic behaviour than to fresh catalyst and also found that their active centre become deactivated which is responsible for the increased the rate of reaction. Therefore it is concluded that disposed catalyst (spent catalyst) from fertilizer industry also have economical value for production of hydrogen and other different purpose.

REFERENCES

1. P.Ratnaswamy, A.V. Ramaswamy, K. Banerjee, D.K. Sharma and N.Kay. *J. Catalyst* **38**: 19 (1975).
2. B.C. Gates, J.R. Katzer and G.C.A. Schuit, Chemistry of Catalytic Processes. (MC Graw Hill, New York) 390-447 (1989).
3. S.N. Chaudhari, D.K. Gorai, B. Yadav, N.C. Ganguli and S.P. sen, "Proceeding of Catalyst society of India ", held at I.I.P. Deradoon (1987).
4. S.R. Naidu, H.Mahapatra, D.K. Gupta, N.C. Ganguli and S.P. Sen, " Proceedings of the symposium on sicnece of catalyst and its application in Industry", Feb. 22-24, F.P.D.I.L. Sindri India 360 (1989).
5. P.B. Tarman and Biljetina, " The steam - Iron Process for hydrogen production", (Paper presented at the 85th National Meeting of the American Institute of chemical Engineer) Philadephia, Pennsylvania, June 4-8 (1988).
6. Nkosi B; Coville, N.J. Hutchings, G.J. Adams, M.D., Friedl, J. and Wagner, F.E., *J. catalyst* **128**: P-366 (1991).
7. "Catalyst hand book" Wolfe scientific books London (1996.).
8. Kozlov, A.I., Kozlova, A.P., Liu, H.C. and Wasawa, Y., *Applied Catalyst* A 182 P-9 (1999).
9. Cunningham, D.A.H., Vogel, W. and Haruta, M., catalyst Lett. **63**: 43 (1999).

10. E.E. Donath- A reprot on hydrogen production, U.S. Agency for International Development, New Delhi (2002).
11. P.J. Van, Berge, J. Vande Loosdrecht, S.Barradas, A.M. Vander Kraan, *catalysis* Today **58**: 321 (2000).
12. Christopher J. Bertole, Challes A. Mims, Gabor Kiss, *J. Catalyst,* 38 (2002).
13. B. Jangsomjit, T. Wongsalee and P. Praserthadam, *Catalyst community* **6**: 705-710 (2006).
14. K.Sapag, S.Rojas, M.L. Gramados, J.L.G. Fierro and S.mendioroz, *J.Mol. Catalyst A-Chemistry* **167**: 81-89 (2005).
15. G.Jacobs, P.M. Patternson, Y. Zhang, T.Das, J.Li and B.H. Davis applied catalyst A general **233**: 215-226 (2004).
16. F.M.T. mendes, C.A.C. Perez, F.B. Noronha and M. Schmal catalyst today **101**: 45-50 (2005).
17. A.N. Akin, A.E. Aksoytu and Z.I. Onsan, *Reaction Kinetic catalyst Lett*. **66**: 393-399 (2006).
18. S.M. Kim, J.W. Bae, Y.J.Lee, K.W. Jun, *Catalysis communication* **9**: 2269 (2008).