Production of Vinyl chloride monomer via Acetylene-HCl reaction

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Background:

Vinyl chloride (CH2=CHCl) is a halogenated alkane. It is the building block for its polymer poly-vinyl chloride (PVC) and other co-polymers with acetate and vinyl chloride. Poly (vinyl chloride), PVC is cost-effective, highly versatile and is used in many construction applications such as water, sewage and drainage pipes, and a variety of extruded profiles. Thousands of rigid, semiflexible and flexible (plasticized) materials and products based on PVC are widely used in practically all spheres of the world economy and will remain so for a very long time. Methods for preparation include:

-Ethylene dichloride thermal pyrolysis

-Acetylene-HCl reaction

-Ethylene dichloride caustic reaction

We have discussed the second method.

Description:

Acetylene and dry HCl in 1:1 molar ratio are vapor blended by jet mixing in a pipe and passed through a tubular reactor containing carbon pellets impregnated with $HgCl_2$. The temperature in reactor is maintained at 160ºC, and is gradually raised to 200ºC as the catalyst deteriorates. The pressure is maintained at 1 atm. The effluent gases contain vinyl chloride along with unreacted acetylene and hydrogen chloride. The unreacted reactants are recycled. The yield of vinyl chloride is 97%.

$$C_2H_2 + HCl \rightarrow CH_2{=}CHCl$$

The above reaction takes place in vapor phase and is exothermic in nature. Control of temperature is the most essential parameter to increase the conversion level.

Conclusion and Recommendations:

Though the acetylene hydrochlorination method has a high rate of conversion and accounts for about 70% of the total VCM production capacity, it utilizes a mercuric chloride catalyst to promote the reaction of acetylene and hydrogen chloride. During the hydrochlorination, the highly toxic mercuric chloride tends to sublime, resulting in the deactivation of the catalyst and also in severe environmental pollution problems. Hence, it is necessary to explore environmental friendly non-mercury catalysts for acetylene hydrochlorination as well as high efficiency novel reactors, with the aim of sustainable PVC production via the acetylene-based method.

Result:

The stream wise results are given below:

Stream Wise Results									
Object	VP	RP-01	P-01	M-03	LP	F-02	F-01	C-01	
Temperature	200	174.628	-19.6213	160.357	200	160	160	174.628	C
Pressure	1.01325	1.01325	1.01325	1.01325	1.01325	1.01325	1.01325	1.01325	bar
Mass Flow	21375.8	543.644	20832.1	21375.8	0	12166.7	8666.67	543.644	kg/h
Molar Flow	353.193	16.9807	336.212	683.493	0	333.691	332.856	16.9807	kmol/h
Molar Flow (Mixture) / Acetylene	10.2155	7.66571	2.54972	340.516	0	0	332.856	7.66571	kmol/h
Mass Flow (Mixture) / Acetylene	265.983	199.594	66.3877	8866.11	0	0	8666.67	199.594	kg/h
Molar Flow (Vapor Phase) / Acetylene	10.2155	7.66571	0.0377853	340.516	0	0	332.856	7.66571	kmol/h
Mass Flow (Vapor Phase) / Acetylene	265.983	199.594	0.983827	8866.11	0	0	8666.67	199.594	kg/h
Molar Flow (Mixture) / Hydrogen chloride	12.5072	9.14506	3.36212	342.808	0	333.691	0	9.14506	kmol/h
Mass Flow (Mixture) / Hydrogen chloride	456.025	333.437	122.586	12499.1	0	12166.7	0	333.437	kg/h
Molar Flow (Vapor Phase) / Hydrogen chloride	12.5072	9.14506	0.0459908	342.808	0	333.691	0	9.14506	kmol/h
Mass Flow (Vapor Phase) / Hydrogen chloride	456.025	333.437	1.67687	12499.1	0	12166.7	0	333.437	kg/h
Molar Flow (Mixture) / Vinyl chloride	330.47	0.169807	330.3	0.169463	0	0	0	0.169807	kmol/h
Mass Flow (Mixture) / Vinyl chloride	20653.8	10.6126	20643.2	10.5911	0	0	0	10.6126	kg/h
Molar Flow (Vapor Phase) / Vinyl chloride	330.47	0.169807	0.252435	0.169463	0	0	0	0.169807	kmol/h
Mass Flow (Vapor Phase) / Vinyl chloride	20653.8	10.6126	15.7767	10.5911	0	0	0	10.6126	kg/h

Reference:

-Dryden’s Outlines of Chemical Technology

-Cleaner Production of Vinyl Chloride Monomer (VCM)

Jemish Dattani, Darshan Devani, Omprakash Sahu

-Progress on cleaner production of vinyl chloride monomers over non-mercury catalysts

Jinli Zhang, Nan Liu, Wei Li, Bin Dai