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Nanofluids as Emerging Working Media in Mass Transfer Operations

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ABSTRACT

The present work is focus on to the synthesis of water based silver nanofluids by chemical reduction method which will increase the surface area of the particles and enhance the rate of mass transfer also to charecterize the thermal properties and mass transfer performance of nanofluids over mass transfer to enhance the efficiency and overall mass transfer coefficient with simultaneous reduction in time . As noated above the basic concept of dispersion solids in fluids to enhance surface area .Compared with micro particles , nano particles stay suspended much longer and possess a much higher surface area. The surface / volume ratio of nano particles is 1000 times larger than that of micro particles. The high surface area of nano particles enhances the mass transfer of nanofluids since mass transfer occurs on the surface of the particle. The number of atoms present on the surface of nano particles , as opposed to the interior ,is very large . Therefore , these unique properties of nano particles can be exploited to developed nanofluids.
Keyword: - Nanofluid, Silver, Chemical Reduction, Mass Transfer

1. INTRODUCTION:

Nanofluid are colloidal suspension of ultra fine metallic or nonmetallic particles in a given fluids. Nanofluids are a new class of fluids engineered by dispersing nanometer-sized materials (nanoparticles, nanofibers, nanotubes, nanowires, nanorods, nanosheet, or droplets) in base fluids. In other words, nanofluids are nanoscale colloidal suspensions containing condensed nanomaterials Nanotechnology provides new area of research to process and produce materials with average crystallite sizes below 100 nm called nanomaterials. The term "nanomaterials" encompasses a wide range of materials including nanocrystalline materials, nanocomposites, carbon nanotubes and quantum dots. Nanofluids can be prepared by a one-step or a two-step method. In the two-step method, the preparation of the nanofluid is isolated from the synthesis of the Nanoparticles.

1.1 Objective of the research work :

- To Prepare the nanofluid with high stability to enhance the rate of mass transfer.
- To estimate mass transfer coefficient (MTC) of nanofluid flowing through a packed column.
- Enhance The Efficiency & Overall Mass Transfer Coefficient Of Pack Column, With Simultaneous Reduction In Area Of Pack Column.
- Develop and transfer nanofluid technology for mould cooling to reduce cycle time.

1.2 Material Used in the process:

The different materials i.e. precursor, reducing agent and stabilizer are depend up physical & chemical properties of the chemical compound and base fluid water. The some important chemical compound used in the project are given below.

1. Precursor: Precursor a chemical compound gives metal particles, when reacts with suitable reducing agent. Considering the thermal conductivity metal silver having highest thermal conductivity i.e.(429 W/m.k). To form metal particles we select silver nitrate as precursor.
2. Reducing agents: Reducing agent is a compound we reduces precursor to obtain nanoparticles by simple reduction reaction. In this project for reducing silver nitrate we select sodium borohydride as reducing agent.
3. Base Fluid: Base fluid are conventional fluids which are use heat transfer application. All conventional fluids such as water, ethylene glycol,etc. can be used as base fluid. In this project we select water as base fluid because water has second most highest value of heat capacity (Cp= 4.18 J/gm/˚c) and the thermal conductivity of water is about 0.613 W/m.k which is highest value among all conventional heat transfer fluid.

2. SYNTHESIS OF NANOFLUIDS:

Yellow colloidal silver has been reported upon reaction with ice-cold sodium borohydride and is the basis for the method used in this work. The determination of an optimum set of conditions for the synthesis of silver nanoparticles is described in the section. An excess of sodium borohydride needed both to reduce the ionic silver and to stabilizer the silver nanoparticles that form. The chemical reaction is the sodium borohydride.

Reduction of silver nitrate: AgNO3 + NaBH4 $\longrightarrow$ Ag + 1/2B2H6 + NaNO3

The silver particles is 12 + 2 nm. The relation between aggregation and optical properties is investigated along with a method to protect the particles using polyvinylpyrolidone on polyvinyl alcohol (PVA).

Fig -1: Synthesis of Silver Nanofluids

2.1 Procedure :

- For Preparing the molar concentration of 0.0001 M Add 0.170 gm of $AgNo_3$ in 1 liter of water. Similarly Add 0.0378 gm of $NaBH_4$ in 2 liter of water for 0.0001 M. Concentration.
- Reactions were done in clean dry 2000 ml. borosilicate conical flask. A 15ml volume of different molarity of silver nitrate was added drop wise (about 1 drop /second) to 40ml of varying molarity sodium borohydride that had been at room temp. without stirred. The entire addition took about five minutes. The clear yellow colloidal silver shown in fig. is stable at room temp. in a transparent vial for as long as several weeks or months. Upon agglomeration the colloidal silver solution turns darker yellow.

Table -1: Nanofluids Synthesis Proportion

Sr. No.	$AgNO_3$ (M)	$NaBH_4$(M)	Proportion	Remarks
1	0.01	0.01	10:30	Blackish color solution obtain and agglomerated particle are seen just after adding $AgNo_3$
2	0.001	0.01	10:30	Pale black color
3	0.001	0.001	10:30	Dark yellow color
4	0.001	0.0001	10:30	Pale yellow color (Satisfied)

2.2 PERFORMANCE OF NANOFLUID OVER PACKED COLUMN:

Packed Absorption Column:

The schematic view of the apparatus used to measure the gas absorption. The column was made of pipe and was filled with marble glass packing. A round flow meter was used to measure the gas flow rate. Rotameter was used to measure the liquid flow rate. Two thermometers (accuracy ±1 ^{0}C) were used at the outlet and inlet of the liquid to measure the liquid temperature. Co2 gas enters from the bottom of the instrument and the fluid enters from the top of the tower as shown in Fig. After steady state condition is achieved, Co2 concentration in the liquid outlet is measured by the titration method. The mass transfer rate (NA) and the mass transfer coefficients (KL) are calculated by the following equations:

3. OBSERVATION FOR ABSORPTION COLUMN :

The nanofluid by chemical reduction Methode is used in packed column for performance analysis. In this study we compared simple cooling water and nanofluid in counter current flow. The result obtain during the practical are as follows Table shows Properties of the Packed Column

Table -2 : Properties of packed colmn

Sr No.	Particulars	Value
1	Height of column	96.67 cm
2	Diameter Of column	16.22 cm
3	Height Of the Packing	45 cm
4	Dai. Packing	1.4 m
5	Void fraction	0.83

3.1 Observations:

Co2 Confirmation Test:

Table -3: CO2 Confirmation Test

Sr. No.	Feed	Volume of sample	Burrete reading
1	Water + CO_2	50 ml	13 ml
2	Nanofluid + CO_2	50 ml	16.3 ml

Calculation of Mass Transfer Rate:

$$Na = \frac{Q}{S*z} * (Co - Ci)$$

Where,

Q = Flow rate of liquid , S = Cross sectional area of column, Z = Height of column

Co-Ci = Conc of inlet and outlet

Concentration of CO_2 In Water and Nanofluid.:

Water	Nanofluid
0.009	0.015
0.012	0.016
0.0130= c*	C*=0.0163

- **For Nanofluid**

$$Na = \frac{1.5}{0.020*0.9} * (0.01683 - 0)$$

$= \underline{1.22*10^{-6}}$ moles/$cm^3.min$

- **For Water**

$$Na = \frac{1.5}{206.52*96.67} * (0.0130 - 0)$$

$= \underline{9.76 * \ 10^{-7}}$ moles/$cm^3.min$

% Increase In Mass Transfer Rate

$$= \frac{1.22 * 10^{-6} - 9.76 * 10^{-7}}{1.22 * 10^{-6}} * 100$$

$= \underline{20\%}$

Calculation of Mass Transfer Coefficient:

$$(Ka)avg = \frac{Q}{S.z} * \ln\left(\frac{C* - Ci}{C* - Co}\right)$$

C* = Equilibrium Concentration. gm/lit.

- **For Nanofluid**

$$Ka = \frac{1.5}{206.52 * 96.67} * \ln\left(\frac{0.0163 - 0}{0.0163 - 0.0160}\right)$$

$= \underline{3 * 10^{-4}}\ min^{-1}$

- **For Water**

$$Ka = \frac{1.5}{206.52 * 96.67} * \ln\left(\frac{0.0130 - 0}{0.0130 - 0.012}\right)$$

$= 1.92 * 10^{-4}\ min^{-1}$

% Increase In Mass Transfer Coefficient

$$= \frac{3 * 10^{-4} - 1.92 * 10^{-4}}{3 * 10^{-4}} * 100$$

$= \underline{36\ \%}$

4. CONCLUSIONS :

In this study, water-based silver nanofluid ($H_2O/AgNO_3$) is being prepared by the One step chemical reduction method is used for gas absorption in a packed column and the following results were obtained:

1. Both the mass transfer rate and the mass transfer coefficient increased with adding the nanoparticles to the base fluid.
2. Mass transfer rate is enhanced by 20% and mass transfer coefficient is enhanced by the 36%.

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