OPTIMIZATION OF THE SOLVENT EXTRACTION RATE AND EXTRACTION EFFICIENCY CONSIDERING FLOW RATE, HEATING RATE, AND SOLVENT CONCENTRATION

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ABSTRACT

Raw cashewnut shell contains around 20 percent oil. When cashewnuts are processed by oil extraction process, about 50 percent oil is extracted. Balance oil (or liquid as it is known) can be further extracted with the help of expellers. This note primarily deals with this kind of processing. Solvent extraction is one of the favored separation techniques because of its simplicity, speed, and wide scope. By utilizing relatively simple equipment and requiring a few times to perform, extraction procedures offer much to the chemists and engineers. Using solvent extraction, important theoretical problems concerning the composition and stability of soluble as well as insoluble complexes can be solved. This paper shows the solvent extraction of cashew nut shell particles using hexane and methanol as solvent. The effect of temperature and solid-liquid ratios had positive influence on extraction rate and extent of extraction which gave the possibility for estimation of initial rate and extent of solid liquid extraction.

Keywords: Cashew Nut Shell Particles, Extraction Rate, Solvent Extractor, Solid-Liquid Ratio, Temperature.

I. INTRODUCTION

As the fossil fuels are depleting day by day, the need for alternate source of energy is atmost concern to our society. As we know that there are various methods for obtaining energy from renewable sources of energy but some of them have found some complications and are economically not feasible for our society. There are many sources of producing energy from renewable sources but it is of great importance to note that biofuels from edible and non edible oils or seeds can be considered as an important source of producing fuels i.e. biofuels which can be converted into biodiesel further and used as fuel in ICengines [3, 5, 7]. Biodiesel from edible oil is not feasible in India because of a big gap between the supply and demand. Plants like Jatropha (*Jatropha curcas*), Mahua

(*MadhucaIndica*), Karanja (*Pongamia pinnata*) and Neem *(Azadirachta indica)* contain 30% or more oil in their sees or fruit [9]. Cashew nut (*Anacardium occidentale*) shell liquid (CNSL) is a unique natural source for unsaturated long-chain phenols .Obtained as a byproduct of the cashew industry, this renewable material has wide applications in the form of brake linings, surface coatings, paints, and varnishes. The main applications of CNSL are in the polymer industry. Compared with conventional phenolic resins, CNSL polymer has improved flexibility (due to the internal plasticization effect of the long chain) and thus betters process ability. The side chain imparts a hydrophobic nature to the polymer, making it water repellant and resistant to weathering. CNSL-based resins possess outstanding resistance to the softening action of mineral oils and high resistance to acids and alkalis. CNSL polymers also have useful characteristics such as heat and electrical resistance, antimicrobial properties, and termite and insect resistance [4]. India being one of the biggest producer and consumer of cashew it becomes very easy for using the cashew nut shell for producing biofuel and biodiesel [6]. CNSL can be extracted by various methods such as hot and cold method [8].

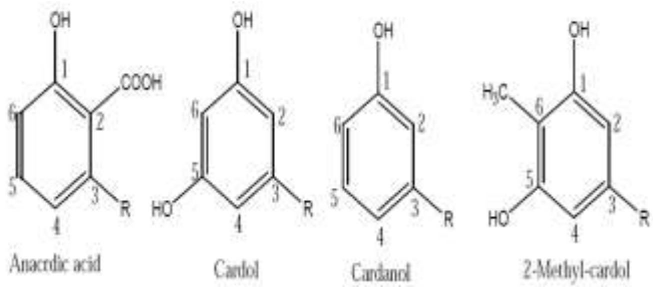

Fig. 1.Structure of main components of CNSL

II. SOLVENT EXTRACTION

This method gives most of CSNL compared to other methods. Extraction solvent may be less dense or denser than water. Hexane and toluene are denser than water and they have a greater tendency to extract oil from the cashew nut shell particles [1]. This method gained its popularity in the recent years as a popular separating technique because of its simplicity, elegance, speed and its wide scope. It has become a very powerful and effective unit of operation in most of the industries. It is a very simple operation apparatus without any sophistication or instrumentation. This unit finds its application in most of the industries such as chemical, metallurgy, nuclear, petrochemical, pharmaceutical as well as in waste management [2].The extraction of CNSL was carried out using a Soxhlet extractor and n-hexane as solvent. Four hundred and fifty milliliters (450ml) of hexane was charged into the round bottom flask of soxhlet apparatus. Subsequently, 60 gram of crushed cashew nut shell was charged into the thimble and fitted into the soxhlet extractor. The apparatus was assembled. The solvent in the set-up was heated to 68^{o}C and the vapor produced was subsequently condensed by water flowing in and out of the extraction set-up. This process of heating and cooling continued until a sufficient quantity of CNSL was obtained. The mixture of hexane and cashew nut shell oil was fed into a vacuum rotary evaporator and the solvent was recovered thus separating the biofuel and solvent. The recovered solvent was used again in the solvent extraction process. The experiment was performed for three hours eight minutes and twenty five siphons were observed so that a sufficient amount of CNSL is extracted. 18 gm of cashew nut shell oil was obtained which is 30percent yield. Similar experiment was also carried out by taking methanol as solvent.

III. EXPERIMENTAL SETUP AND WORKING PRINCIPLE

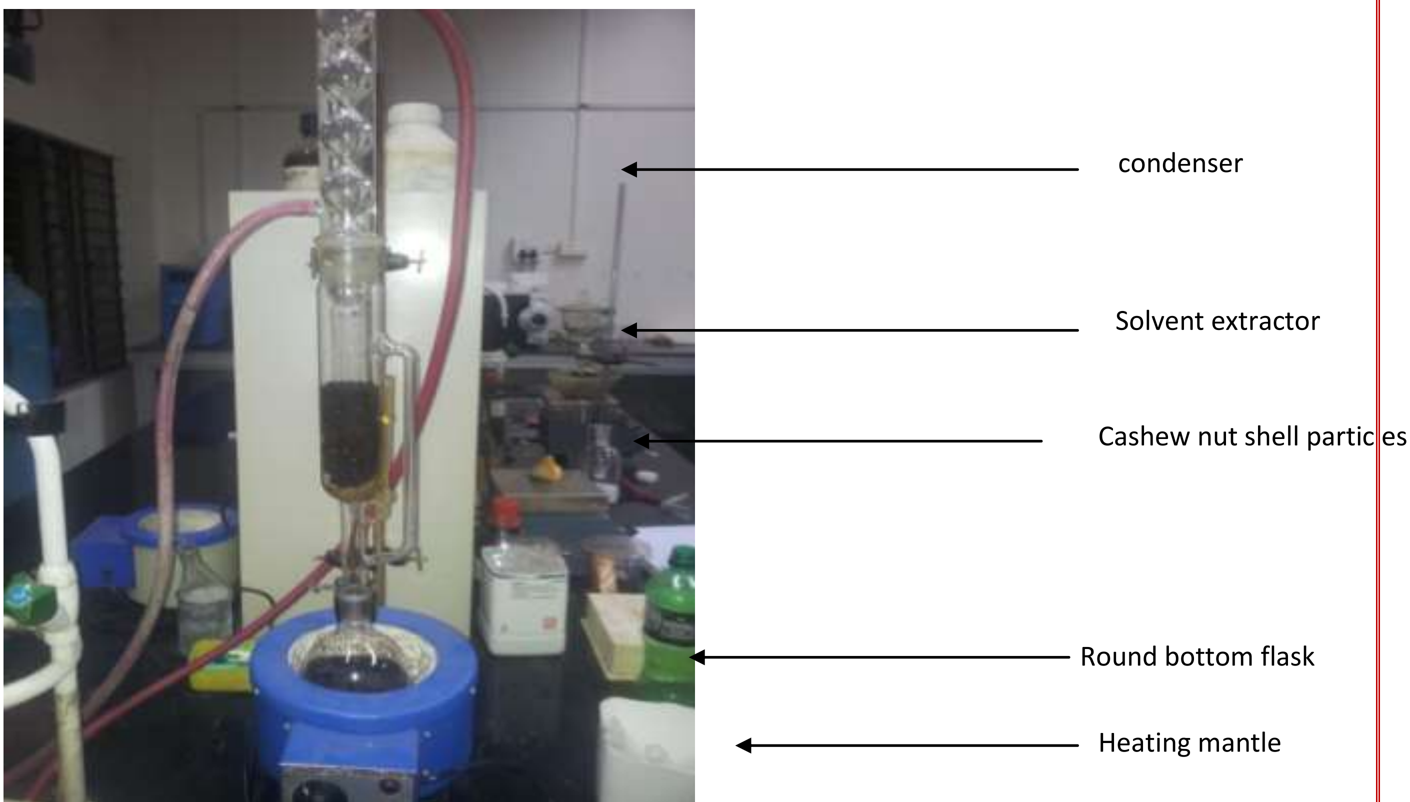

Fig. 2. Components of the solvent extractor

The set up mainly consists of a round bottom flask an extractor and a condenser. The solvent is fed into the round bottom flask and the sample is kept in the extractor which is in the mid position. The round bottom flask is heated by a heating mantle which is connected to the ac supply. When the solvent in the round bottom flask gets heated up to its boiling point then the vapors of the solvent starts rising up and passes through the condenser and condenses the solvent vapor which falls into the sample present in the extractor i.e. the cashew nut particles. When the level of condensed vapor increases then it comes out of a tube which carries the liquid from a higher level and up and over a barrier and down to the round bottom flask. This siphon continues when the level of liquid inside the extractor increases. After sufficient number of siphons the required amount of biofuels is obtained and thus the experiment continues with the same process. After the extraction is over the mixture of the solvent and fuel is fed into a vacuum rotary evaporator for separating the mixture and the solvent is recovered for further use in the solvent extraction process.

3.1 Experimental Results

Amount of n hexane in the round bottom flask	450milliliters
Amount of cashew nut shell particles	60 grams
Amount of biofuel obtained	18 grams
Percentage yield	30 percent
Total time taken for the experiment	3hours and 8 minutes

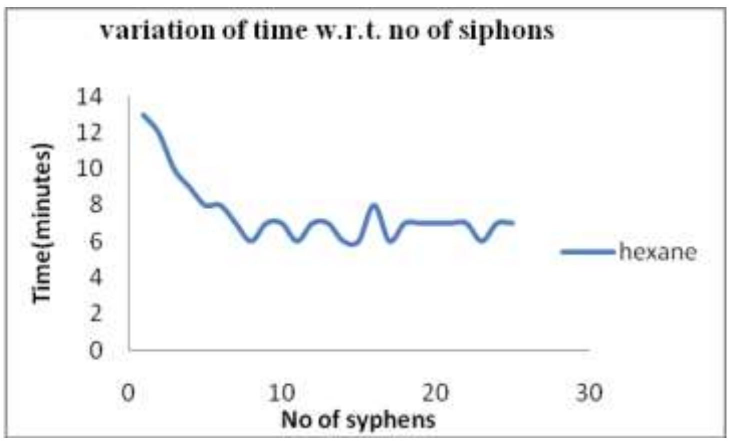

Fig. 3.Variation of time w.r.t. number of siphons using hexane as solvent

Amount of methanol in the round bottom flask	500milliliters
Amount of cashew nut shell particles	70 grams
Amount of biofuel obtained	17.5 grams
Percentage yield	25 percent
Total time taken for the experiment	5 hours 32 minutes

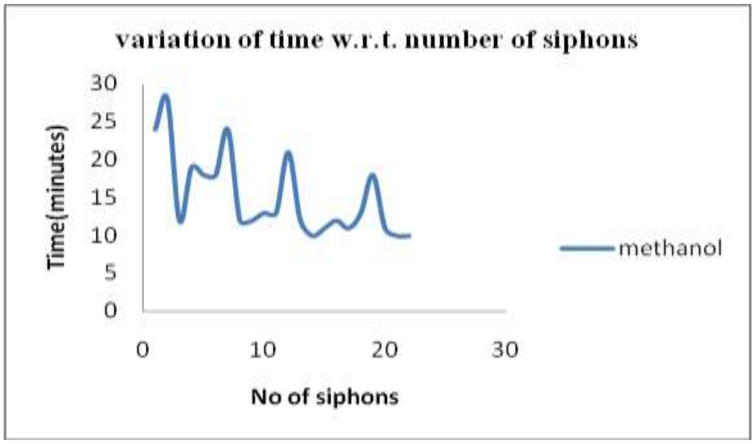

Fig. 4. Variation of time w.r.t. number of siphons using methanol as solvent

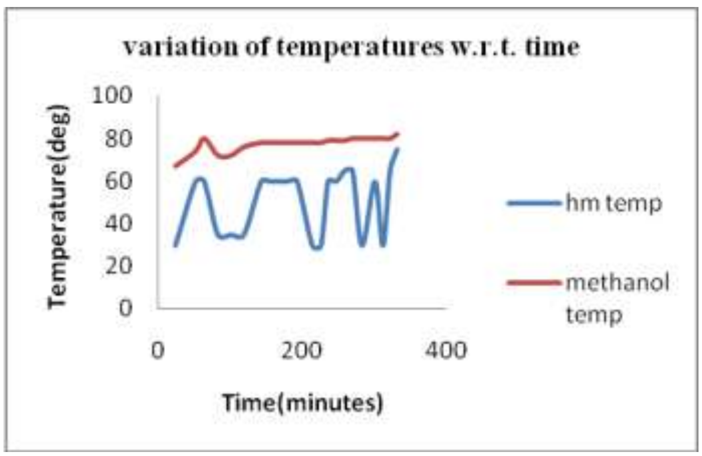

Fig. 5. Variation of methanol temperature and heating mantle temperature w.r.t. time

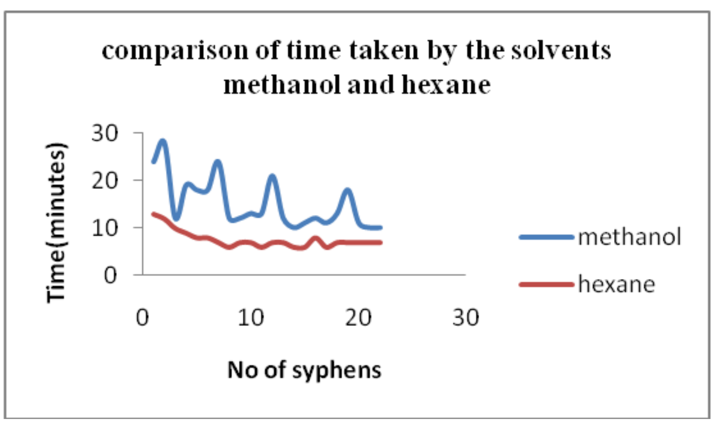

Fig. 6. Comparison of the time taken for both the solvents i.e. hexane and methanol for solvent extraction

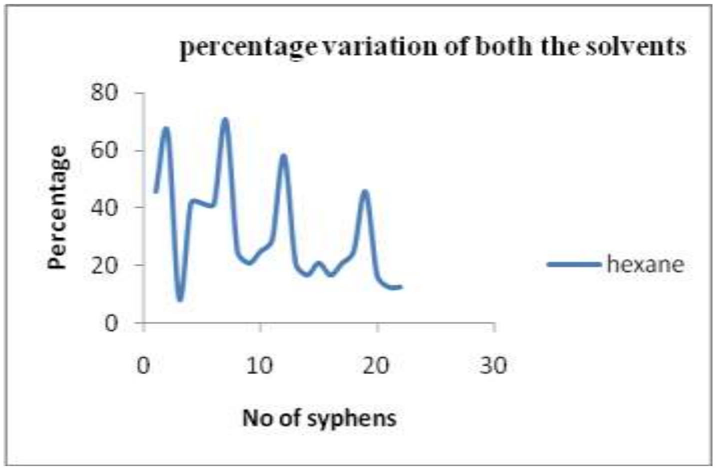

Fig. 7. Percentage variation of the solvent hexane w.r.t. methanol

3.2 Discussion

Fig. 3 shows the time taken by hexane w.r.t. the number of siphons which is less compared to the time taken by methanol as shown in the Fig. 4. Thus we can say that hexane is a better solvent for extraction process and the yield of extraction is also more than that of methanol.Fig. 5 shows the temperature of the heating mantle and the temperature of the solvent methanol. When heating mantle is at a particular temperature the solvent temperature attains some value due to which the boiling of the solvent starts and vapor starts moving upward towards the condenser. At a particular time the temperature attains an equilibrium value for which the heating mantle temperature is slightly maintained at a lower temperature than that of the solvent. There is always a temperature difference between the solvent and the heating mantle. If same temperature is maintained in both the solvent and the heating mantle than the wall of the extractor gets heated up and no siphon occurs. Further the condensed vapors when fall on the cashew shell nut particles the temperature of the liquid falling in the round bottom flask decreases for which an increase in the heating mantle temperature is required. Continuously siphons occur and maximum amount of biofuel is extracted from the sample.Fig. 7 shows the percentage variation of the solvent hexane w.r.t. methanol. It can be clearly seen that the percentage of hexane for the siphon to occur in less amount of time is more than that of methanol. In every siphon it is observed that the solvent hexane requires less amount of time to perform the extraction as compared to methanol thus making hexane a good solvent.

IV. CONCLUSION

The experiments carried out showed that the extraction of oil from the cashew nut using hexane as solvent is much more effective than methanol. Moreover methanol takes much more time in extraction process than hexane and the quantity of biofuel obtain from hexane is 30percent compared to methanol which is 20 to 25 percent. As shown in the Fig. 7 the number of siphons being constant the extraction rate is much more in case of hexane than that of methanol. Solvent extraction by means of soxhlet apparatus has a positive attribute because of the use of limited quantity of solvent more amount of oil can be extracted in a shorter time. This extraction technique is better than the conventional mechanical expeller method as some amount of oil still remains in the cashew nut shell particles after taking out of the mechanical expeller which can be extracted using solvent extraction process.

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