

Recovery & Analysis of Spent Solvent from Paint Coating Industry through Fractional Distillation for Sustainable Waste Management.

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Abstract - From the product of human protection medicine to the manufacturing of synthetic paint & plastics, solvents play a dynamic function in new age society. However, they share one thing in common-all the world's production of solvents ultimately ends up being desolated or dissipated into the atmosphere. There is an inconsequential collection of solvents in long-tenure artefacts so the yearly production of the solvent industry equates nearly to the discharge. Due to considerable causes generated in paint industries by dangerous waste and its probable causes, solvent recovery and analysis as a measure of sustainable waste management were scrutinized. However, the usual denominator is that the solvent used in paints is much more poisonous and may result in environmental pollutants or fitness problems. The volatile organic compounds (VOC) observed in paint are dangerous to the climate as well as the people working out around paint and their donation to the whole is correspondent equal to all the VOC turning out from the fuel and operation of engine vehicles. The input raw materials in paint manufacturing, the roots of spent solvent, the classes and properties of solvents used in paint industries, and recovery methodologies were also inspected. The recovery and analysis of spent solvent acquired from the laving of different furbish paint manufacturing pots using MEK, toluene, and cyclohexane as washing solvents were carried out on a laboratory scale by separation, filtration, and distillation operations. These techniques were handpicked because they are the most productive and cost-efficient of the various techniques reviewed. The results displayed that the average recovery of spent solvent is 82% which is recyclable and reusable. Analytical results of recovered spent solvent gave a mild sweet odour and a clear/colourless liquid. Other physical properties of the recovered solvent are density 0.900 gm/cc at 240C, boiling point 118oC, and flash point 4oC. These specifications are similar to those of fresh solvent and thus can be reused.

Key-Words: Recovery, Analysis, Spent Solvent, Fractional Distillation, Paint Coating industry, Sustainable waste management

1. INTRODUCTION

The human influence on the environment has become a major concern as the world's population continues to expand at a rapid pace. As the world's population grows, so does the demand for man-made things also increases with respect to increase in waste. Natural wastes are easy to dispose but man-made wastes are expensive and difficult to dispose of which leads to environmental degradation. Due to these reasons, environmental sustainability becomes a matter of concern for this, it can be convenient to keep down the use of man-made products and minimize waste. With respect to minimizing

waste, recycling and reuse can be the best solution for sustainability.

In some situations, the cost of recycling or disposing of the product is higher than the cost of manufacturing the product, and the cost is not profitable, so the companies avoid recycling waste. In view of this degradation of the environment, the government has imposed some mandatory rules on the companies in which it is the responsibility of every company to recycle or manage the waste generated from its factory.

Paint brings colour to the world and differentiates every object. Paint is a mixture of a pigment and suitable liquid to form a closely adherent coating when spread on the surface in a thin coat to impart decorative as well as protective properties. Generally, paint consists of a mixture of resin, pigment, additives, solvent, and other necessary ingredients.

The purpose of the paper is to focus on solvent which plays a vital role in paint. In paint, solvents dissolve or disperse the compounds used in the paint formulation to make paint the desired viscosity for application and to avoid clumps or globs. The solvent evaporates quickly, allowing the resin and pigment to produce a film of paint and dry faster. Adding solvent in paint formulation helps to optimize the whole performance of the systems.

Solvent has extensive properties in paint formulation, it is also used as a washing chemical in the paint coating industry to clean equipment, rolls, and holdings pots. After the washing off equipment, solvent waste is generated which contains the paint particle and due to this particle contamination, the solvent cannot be reused for the next wash.

Reuse after recovery of spent solvent would reduce the amount of waste solvent disposed of as waste. This recovery of spent solvent waste reduces environmental pollution with hazardous effects and improves environmental sustainability.

Since the manufacturing process involves the use of pigments (different color) and resins, it is necessary to clean the equipment before another batch of coating. This paint coating has different shades, and rolls of the calendaring process need to be cleaned at every batch to avoid rejection. This process is known as washing which is carried out to prevent clogging, and contamination and to clean the machine for the next process.

Because of the nature of the component used in the paint coating process, solvents are the best option for the washing process and it leads to solvent wastage. At ENTREMONDE POLYCOATERS LTD, NASIK is the example for this study. It was found that around about 180 to 220-liter solvents were required to wash after every batch completion.

The solvent recovery process is a quite confusing task where many facts take into consideration like the nature of spent solvent, sludge disposal, process cost, the quality parameter of the recovered solvent, safety, and government norms. The best process selection for the recovery process is to achieve the highest recovery of quality solvent by reducing machine and process costs by taking measures of pollution control and safety. Selected processes of recovery have the consideration the nature of waste, properties of the solvent, and expected use of recovery solvent.

By taking all facts into the consideration Fractional distillation with condensation is a great choice for solvent recovery. A physical and chemical parameter of solvent gives the fundamentals to the recovery process. Its boiling point, melting point, relative volatility, density, and flash point help to optimize and set up the process parameter.

This work is focused on the recovery of spent solvent from paint coating industries by analyzing process parameters to achieve the best quality at minimum cost and also explains the best recovery method with consideration of government norms. This will reduce the quantity of waste generated from the paint coating industry and improve sustainable waste management, on the other hand, reduce the cost of solvent in the local market's need where the recycled solvent can satisfy the need for a fresh solvent.

2. EXPERIMENTAL PROCEDURE

There is various kind of experimental procedure for recycling spent solvent waste but every procedure has its own advantages and disadvantages with respect to the raw material (input) we provide.

Different kinds of solvents are used for washing of production equipment in ENTREMONDE POLYCOATERS, NASHIK including MEK, cyclohexane, xylene, and toluene. Spent solvent waste is the mixture of solvents including paint ingredients like resin, pigment, and additives, where 90-95% are solvent and 5-10% are solid material.

Solids contained in a waste solvent can be separated by settling and filtration or layer separation technique. The spent solvent is kept in separation and allowed for settling for about 10 to 15 min so it forms a layer of solids at the bottom and solvent at the top due to density difference. A layer of solids is taken out from the separator and solvent is taken for further processing.

Fractional distillation is used for the recovery of spent solvent as per the concern of the central pollution control board. Paint solvent hazardous waste comes under the category of 21.2 mentioned in Schedule I.

Central pollution control board introduced a standard operating procedure for the utilization of spent solvent for recovery of solvent and instructed to use of fractional distillation followed by two-stage cooling where water shall be used as the cooling medium for condenser for recovery of mixed spent solvent having a boiling point of 100°C and above whereas for solvents with low boiling point (i.e. <100°C) shall provide secondary condenser with chilled water/brine as cooling medium

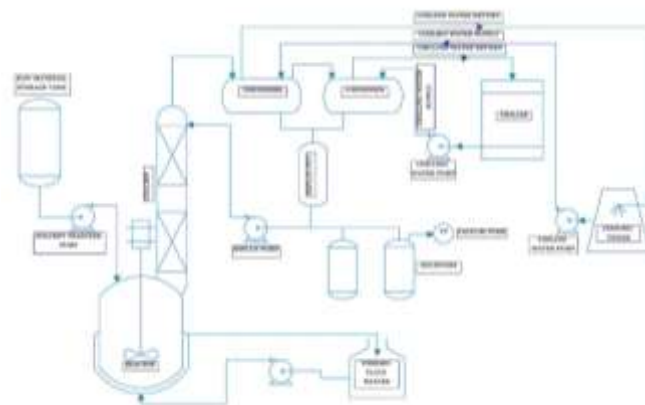


Fig -1: PFD of Solvent recovery



Fig -2: Experimental setup of solvent recovery

Residue generated from the distillation process shall be packaged and temporarily stored in a dedicated hazardous waste storage area. The same shall be disposed in common hazardous waste treatment, storage and disposal facility (CHWTSDF) or sent to cement kilns for co-processing /utilization at facility.

To determine the quality parameter and specifications of recovered solvent, some physical properties were analyzed like color appearance, density, boiling point, melting point, viscosity, RI and odour.

3. RESULTS & DISCUSSION

For this experiment, a 500 ml spent solvent sample has been taken and about 460 ml sample has recovered where it took 80-90 minutes at atmospheric conditions. The experiment is carried out at 120-140°C. At the temperature of 118 first drop of distillate is observed and at the temperature of 140°C, the last drop of distillate is observed.

From this experiment and Table 1 indicates that recovery of solvent from spent solvent which is generated from paint coating industry is about 80 to 85 %. Recovery of mix solvent at atmospheric pressure would increase the process time which can be reduced by applying vacuum pressure that help to reduce process time and process cost also. Temperature for mix solvent is set at 140°C gives a best recovery rate.

Table 1: Comparison of physical properties of fresh solvent with recovered solvent

Sr. No.	Physical properties	Instrument used	Recovered Solvent	Fresh Solvent
1	Odour	Orally	Mild Sweet Odour	Sweet Odour
2	Appearance	Vison	Pale Green	Clear Liquid
3	Density (g/cc)	Hygrometer	0.900	0.890
4	Boiling Point (°C)	Boiling Point apparatus- Thermocal25	102	110
5	Flash Point (°C)	Abel Flash point apparatus	2.8	4
6	Viscosity (cp)	Ostwald viscometer	1.783	1

Table 2: - Cost Estimation

A] Process cost = Electricity + Fuel + Manpower

Energy Consumption					
Sr. No.	Equipment	Equip ID	Capacity	Power Req.	Energy (KWH)
1	Raw material storage tank	ST-01	3 KL	-	
2	Solvent transfer pump	P-01	400 M3/HR	03 HP	2.24
3	Reactor	SSR-01	4 KL	10 HP	7.46
4	Fractionating Column	CL-01	05 MTR	-	-
5	Condenser	C-01	15 M2	-	-
6	Condenser	C-02	5 M2	-	-
7	Reflux pump	P-02	300 M3/HR	03 HP	2.24
8	Reflux pot	RP-01	200 Lit	-	-
9	Receivers	RC-01,02	1.5 KL	-	-
10	Vacuum Pump	VP-01	50 CFM	05 HP	3.73
11	Chiller	CH-01	7.5 TR	-	-
12	Chilling water pump	P-03	4500 LPH	03 HP	2.24
13	Cooling Tower	CT-01	50 TR	03HP	2.24
14	Cooling water pump	P-04	15000 LPH	05 HP	3.73

15	Thermic Fluid Heater	TFH-01	75000 Kcal/Hr	7.28 Kg/hr LDO	-
16	Thermic fluid transfer pump	P-05	25 M3/HR	05 HP	3.73

B]

Batch Size	3800	Lit
Recovery rate	90-92	%
Output received	855	Lit/Hr
Operating hours	4	Hr
Total Electricity	27.6	KWH
Total Fuel (LDO)	7.28	KG/HR

Fractional distillation is best recovery technique which constraint the property of solvent but there was slight difference the property of recovered solvent includes density, Viscosity, Boiling Point, Flash Point. In the opinion of cost estimation, fraction distillation can save the 12% of amount from the recovery of solvent compare to fresh solvent where 0.032kwh electricity and 0.0085kg/hr required for recovery of one liter spent solvent.

4. CONCLUSIONS

This experiment has shown that the recovery of spent solvent is 71% from the waste generated from the paint coating industry and can be reuse for the washing of production pots & equipment and also fulfill the requirement of local market where solvent is used for the purpose of thinner. This work is most helpful which gives an idea about spent solvent recovery, process choice with detailing and its benefits and import ants of sustainable waste management.

The process of settling, filtration and fractional distillation has various kinds of rules and regulations to operate at industrial scale which reduce the financial benefits of recovery but it helps to reduce and maintain the pollution created by the solvent waste. Fractional distillation process is economically suitable but there is slight difference in property of fresh solvent and recovered solvent.

RECOMMENDATIONS

It is advised that recovered solvent can be reused for the washing of production equipments and as a thinner in local paint shop which helps to reduce the volume of waste solvent.

The work zone and experimental area shall maintain proper ventilation. Personnel involved in the plant operation shall wear proper personal protective equipment such as hard hats, goggles, face shields, steel toed shoes, gloves, aprons, respirators etc.

The packing of product (i.e. recovered solvent) shall be labelled as "This product has been recovered from Spent Solvent generated from paint coating manufacturing process."

During loading and unloading of spent solvent/recovered solvent from tanker to storage tank or storage tank to tanker, vent (of both storage tank/tanker) shall be

connected to each other so as to minimize VOC emission. Vent of all storage tanks shall be conned through condenser.

The vent of condenser shall be at least 06 meters above the roof top. The vent of condenser shall be passed through VOC absorption media like activated carbon. Regular VOC monitoring with portable VOC meter at primary and secondary vent condenser should be compulsory.

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BIOGRAPHIES



Accomplished Chemical Engineer and entrepreneur with over eight years of diverse industrial experience, specializing deeply in advanced separation processes. As the Founder of Cytomin Herbals & Healthcare and Executive Partner at M/S IRA Pharma, leverages robust technical expertise and real-world operational insights to bridge the gap between academic theory and industrial practice. Lecturer at department of chemistry of Art science and commerce college, ozar mig