REMOVAL OF PETROLEUM-SOLVENT VAPORS FROM THE EXHAUST AIR OF DRY CLEANING FACILITIES

M.Eić, M. Couturier and M. Jama
Department of Chemical Engineering
University of New Brunswick, Fredericton, NB
Canada E3B 5A3

Introduction

The dry cleaning industry is now under increasing pressure to reduce the impact that the solvents used for fabric cleaning are having on the environment. Perchloroethylene which has become the most popular solvent in the last twenty years because of its high cleaning power, is now under close scrutiny by environmental groups and governments because of its toxicity. As a result the petroleum solvents, which were widely used before the arrival of perchloroethylene, may regain their original popularity since they are considered less damaging to the environment. Nonetheless, to meet future environmental regulations, plants that use petroleum solvents will also need to reduce solvent emissions, in particular air emissions. This can be most efficiently achieved by removing organics using an adsorption bed and recycling the solvent after regeneration.

The main objectives of this study include

a) screening of candidate adsorbent materials for the removal of petroleum vapors from air,
b) finding optimum operating and regeneration conditions for the selected adsorbent, and
c) building and testing a prototype.

Experimental

The bench scale experimental set up consisted of a 10 cm long and 2.5 cm I.D. adsorption column, a GC instrument with an FID detector to measure total hydrocarbon effluent concentrations and auxiliary equipment. A schematic of the experimental set up is shown in Figure 1. Nitrogen or air was used as a carrier gas and was saturated with petroleum solvent vapors in a gas bubbler operating at ambient conditions. All breakthrough experiments were carried out at 20°C, 1 atm and gas flow rates between 250 and 350 cm^3/min. The average particle size of the adsorbent material used to pack the column was 2.8-3.3 mm.

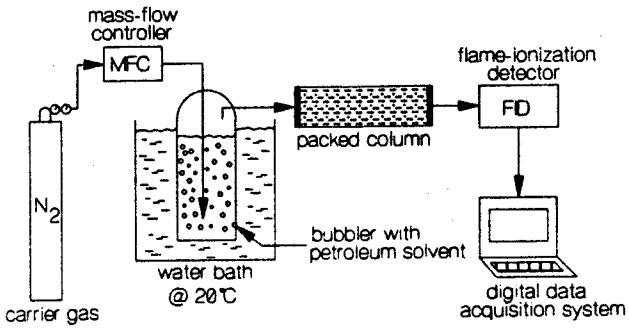

Figure 1. Apparatus for screening adsorbents.

Results and Discussion

Three types of adsorbent materials were tested:

- activated carbon (Xtrusorb 800, Calgon carbon), and
- two silicalite (zeolite) samples (SA-5 and S-115 UOP, Union Carbide division)

Xtrusorb gave a sharp breakthrough curve (Figure 2) and had a high adsorption capacity of 0.76 g/g. In contrast, the silicalite samples gave a 2-step breakthrough response; the first step likely corresponds to the breakthrough of light hydrocarbons (very low capacity), and the second step to the breakthrough of heavier organics. Because the Xtrusorb sample has a high capacity for both light and heavy hydrocarbons, it is considered an excellent adsorbent for removing petroleum-solvent vapors from the exhaust air of dry cleaning facilities. The silicalite samples are poorer candidates for this application.

A number of tests were also conducted to find optimum regeneration conditions for the activated carbon. Regeneration with air at 130 to 140 °C for 4 to 5 hours using a superficial velocity of 0.15 m/s was found to be optimum.

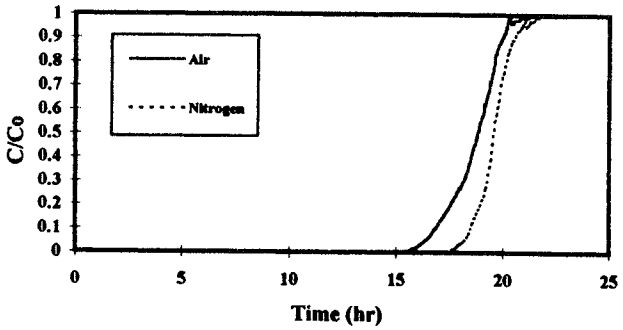

Figure 2. Xtrusorb-800 Breakthrough Curve. Carrier flow rate = 350 cc/min

Prototype

In the dry cleaning industry, the solvent used for cleaning the fabrics is removed by evaporation in a hot-gas dryer. Modern dryers use a closed re-circulation loop for this purpose. After having passed through the garments, the hot air is passed over a condenser to remove the evaporated solvent and then reheated over a steam coil before being sent back to the rotating garment tumbler. At the end of the evaporation process, the concentration of organics left in the air within the system is dictated by the volatility of the solvent at the operating temperature of the condenser. Unless these organics are removed by adsorption, they are discharged to the environment when the dryer is vented.

To demonstrate that adsorption beds can be retrofitted on existing dryers, an adsorption system was built to reduce solvent emissions from the dryer at a dry cleaning plant in Miramichi, N.B. A schematic of the prototype is shown in Figure 3. It consists of a single adsorption bed, a water-cooled condenser, a steam heater and a blower. The adsorption column is 0.5 m in diameter, 0.8 m high and is packed with Xtrusorb 800 activated carbon.

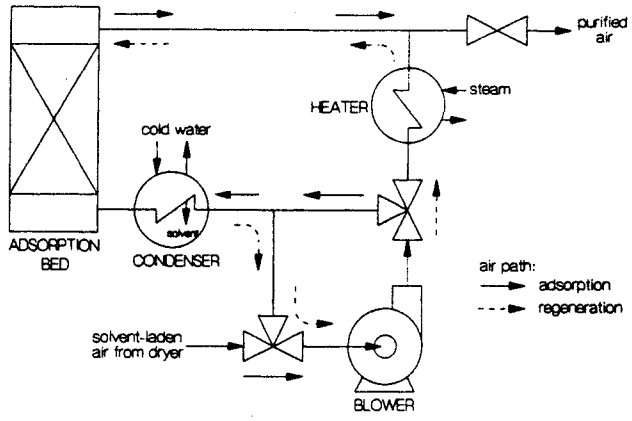

Figure 3. Prototype

The prototype is simple to install, does not interfere with the normal operation of the dryer and requires no special attention from the operator. During the last 5 minutes of the drying cycle, a timer activates the blower on the prototype to draw solvent-laden air from the dryer. After leaving the blower, the air passes first over the condenser and then flows upward through the adsorption bed at a superficial velocity of 0.3 m/s before being discharged outside. As air is withdrawn from the dryer, it is replaced by clean room air and this leads to a decrease in the solvent concentration within the dryer.

The adsorption bed was designed to operate in the manner described above for a cumulative time of 8 hours. When the bed approaches saturation, it is regenerated in about 5 hours using hot air at 130°C and a superficial velocity of 0.15 m/s. The operator initiates this process by turning on the heater, condenser and blower and by adjusting the two 3-way valves to force the air to circulate in a closed loop around the heater, adsorption bed and condenser. In this manner, the solvent is desorbed from the activated carbon by the downward flowing hot air and recovered at the condenser.

The results of the tests performed on the prototype will be presented at the conference.

Conclusions

- The activated carbon Xtrusorb 800 was found to be an excellent adsorbent for the removal of petroleum-solvent vapors from air.
- A compact adsorption system was built and successfully installed at a dry cleaning plant to reduce VOC emissions from its dryer.

Acknowledgments

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