Chemical Distillation at MTFs

FACT SHEET 37-040-0411

1. BACKGROUND. Because of their role in tissue processing, formalin, ethyl alcohol (ethanol), and xylene are among the most common chemicals used in medical treatment facility laboratories. Formalin, an aqueous solution of about 37% formaldehyde (and some buffer salts), is typically diluted to 10% and used as a fixative to preserve tissue samples until they can be prepared for viewing. To prepare tissue samples for viewing, the tissue must be sliced, placed onto slides and stained. However, before a tissue sample can be sliced, the water within its cells must first be replaced by paraffin which gives the tissue a rigid structure and prevents the cells from becoming distorted by the cutting blade. This replacement process involves submerging the tissue in a series of graded ethanol solutions, then xylene, then paraffin. Once cut, the tissues slices (containing paraffin) must then be taken through the graded series in reverse to replace the water in the cells, allowing them to be stained. Then, the stained samples are taken back through the series one last time to replace the water with paraffin for long-term preservation.

2. DISPOSAL. Once the initial tissue sample has been removed from the fixative, the used formalin may typically be disposed of via the sanitary sewer (unless there are local wastewater regulations prohibiting such a practice). Used ethanol and xylene, however, must be managed and disposed of as hazardous wastes.

3. DISTILLATION. As an alternative to disposing of these used chemicals, distillation provides a mechanism to reclaim and reuse them. Distillation separates a liquid from its contaminants by heating the liquid until it vaporizes. The vapors are then collected and condensed while the contaminants are left behind in the boiling chamber as still bottoms. Distillation can be used to recover formalin, ethanol, and xylene. However, the process for recovering formalin differs from that used to recover ethanol and xylene. This difference results from the nature of each of these waste streams.

a. Formalin. Used formalin is typically contaminated only with tissue particles. As a result, the distillation process only has to separate the formalin from particulate contamination. This can be accomplished with a process known as simple distillation. Simple distillation is used to separate volatile components from non-volatile ones. Therefore, the water and formaldehyde in the formalin mixture will be vaporized, condensed and collected while the non-volatile tissue cells or particles will comprise the still bottoms. The distilled formalin will have the same or very nearly the same concentrations of formaldehyde and water as did the original formalin. One drawback, however, is that any buffer salts in the formalin will remain behind as still bottoms. Therefore, before reuse, it would be necessary to replenish these salts. Kits of pre-measured salts are available from some formalin distillation unit manufacturers that can be added after each batch of formalin is processed. Test kits are also available to help assure that the formalin has been restored to specifications.

b. Ethanol and Xylene. The recovery of used ethanol and xylene is more complicated. This is because they are contaminated not only with particulate but also with other volatile substances. If the laboratory segregates its used ethanol and its used xylene, the ethanol will probably be contaminated with tissue cells as well as volatile substances such as water, formalin, and tissue stains. The used xylene could be contaminated with tissue cells, paraffin, and ethanol. If a laboratory does

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not practice waste segregation, its waste will contain any or all of the above. Separating a mixture of multiple volatile compounds into its various constituents (or fractions) requires a process known as fractional distillation. Fractional distillation relies on each volatile constituent having different vaporization and condensation temperatures than the other constituents in the mixture. For waste ethanol (contaminated with water and tissue stains), fractional distillation can recover up to 90% of the ethanol (with 10% left behind in the still bottoms). The distilled ethanol will be up to 95% pure (with water as the remaining 5%). For waste xylene (contaminated with ethanol and water), fractional distillation can recover up to 95% of the xylene (with 5% left behind in the still bottoms). The distilled xylene can be up to 100% pure. For laboratories with combined waste streams (used ethanol and xylene mixed), most fractional distillation units would only be effective in recovering the xylene portion of the waste stream. As a result, it is recommended that histology laboratories maintain proper waste segregation.

4. SUMMARY. The following table provides a summary of the above information. Depending on the amount of waste being generated, distillation units of varying sizes are available, ranging from units that will recycle 10 gallons per batch to units intended for smaller operations that will recycle 1-2 gallons per batch. Additionally, some units are entirely self-contained and do not require water or ventilation hook-ups.

Distillation Unit Summary

Substance	Distillation Type	% Recovered	% Purity	Batch Size (gallons)	Cost per Unit ($)
Formalin	Simple	90	100*	1-2.5	10000 to 15000
				5-10	17000 to 25000
Ethanol	Fractional	90	95	1-2.5	10000 to 15000
				5-10	17000 to 25000
Xylene	Fractional	95	100	1-2.5	10000 to 15000
				5-10	17000 to 25000

*After replenishing with buffer salts.