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Original Research Article

Acetone Reclamation: An Affordable and Practical Approach to Recycle Impure Acetone from Plastination

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ABSTRACT

Dehydration of the tissues with acetone is one of the critical phases of the plastination procedure, and much acetone is utilized in this step—the present study aimed at acetone reclamation with essential laboratory equipment cost-effectively. The objective was to use the reclamated acetone and not discard it in the environment. In this experiment, 150 liters of impure (used) acetone was taken for reclamation through a simple distillation method. The Institutional Ethical Committee (IEC) of Symbiosis Medical College for Women, Pune, approved the study. Essential laboratory equipment included two heat-resistant glass jars with stoppers, ½ a diameter stainless steel tube, a cooling chamber, a thermostat-controlled hot water bath, an electrode pH meter, and a laboratory thermometer. The cooling chamber condensed the boiling acetone vapours, and pure acetone was collected in the glass jar. The results were calculated using descriptive statistics. With this acetone reclamation setup, 150 liters of impure acetone were recycled, and 128 liters of acetone with a purity of 97% - 99.3% was recovered. The essential equipment for this study pre-existed in our laboratory. The current study also proposes installing a cost-effective acetone reclamation unit at plastination labs to avoid disposing of the impure acetone as toxic waste, thus preventing it from harming the environment.

KEYWORDS: Acetone recycling, acetone reclamation, chemical hazards, cost-effective plastination.

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INTRODUCTION

Anatomist Gunther von Hagens developed the "plastination" method, i.e., the process of body preservation or their parts for use in 1977 [1]. Pliable plastics were used to replace the water and fat, resulting in specimens that do not smell or degrade with the preservation of maximum of the original characteristics [2, 3]. Fixation, the initial step of plastination, often employs a formaldehyde-based solution to preserve tissues from decomposition [4, 5]. The tissue is then immersed in an acetone bath with a freezing point of -95 °C (-139 °F) and maintained at a temperature range of 20 and 30 °C (-4 and -22 °F) [6]. Subsequently, the tissue is submerged in a liquid polymer bath such as epoxy resin, silicone rubber, or polyester and cured using ultraviolet rays or

natural sunlight [7].

Acetone is a colourless fluid with a discrete smell and a pH range of 6.5 - 7 [8]. It is highly combustible, volatile, and water-soluble [9]. One of the crucial steps of the plastination technique is the dehydration of the tissue, which is accomplished with the help of acetone [10]. The volume of the acetone should be ten times that of the specimen, and three acetone changes need to be adopted for the dehydration and defatting process [11]. The dehydration contaminates the acetone with water and lipids, making it a hazardous waste, and subsequently, fresh acetone needs to be purchased for future requirements [12].

Industrial-graded 99% pure acetone costs around 500 to 600 INR per litre [13]. The cost of ready-made acetone recycling equipment, which can recycle 15 litres of acetone daily, commences at a minimum of 5 lakhs [14]. The methods currently available for recycling acetone are freeze separation, molecular sieve extraction, vacuum distillation and physical water extraction; however, these processes require a secure lab environment and high-tech tools [15]. The literature describes numerous acetone recycling techniques with cost, safety, and time commitment limitations. To address this issue and fill the lacunae, this study attempted to design a cost–effective, simple, environment-friendly acetone reclamation setup. Therefore, the present study aimed at cost-effective acetone reclamation with essential laboratory equipment and using recycled acetone without discarding it in the environment.

Study Design: In this experimental study, 150 liters of impure (used) acetone was taken for the reclamation through a simple distillation method. The Institutional Ethical Committee (IEC) of Symbiosis Medical College for Women, Pune, approved the study. Reference: Proposal No. SIU/IEC/179 dated 11/11/2020.

MATERIALS

150 liters of contaminated acetone, collected from dehydrated dissected human specimens, were used in this experimental study. This acetone was graded according to its impurity levels into a grade (I) 50 liters, grade (II) 50 liters, and grade (III) 50 liters and taken for reclamation. Essential laboratory equipment included two heat-resistant glass jars with stoppers, ½ a diameter stainless steel tube, a plastic container, a thermostat-controlled hot water bath, an electrode pH meter, and a laboratory thermometer.

Apparatus setup: The stainless steel tube connected the two glass jars [jar – (a) and jar – (b)] through an airtight cork to the plastic container filled with ice cubes (cooling chamber). Consequently, the glass jar – (a) was filled with impure acetone and placed in the hot water bath with a boiling temperature of 55^0 – 60^0C. The vapours were then condensed by the cooling chamber, leading to the collection of pure acetone in jar – (b), as shown in Figure 1.

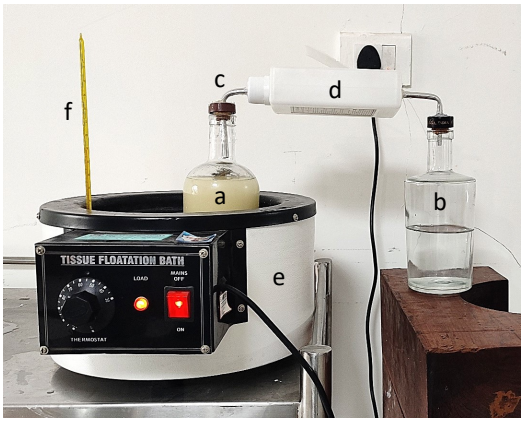

Fig. 1: Shows the cost-effective acetone reclamation setup
a. impure acetone, b. pure acetone, c. stainless steel tube, d. cooling chamber,
e. thermostat-controlled hot water bath, f. laboratory thermometer.

Fig. 2: Comparison between impure and acetone reclamation.
a. impure, pale-coloured acetone with a layer of fat and debris. b. pure, colourless and transparent acetone

Fig. 3: Impure acetone readings in the pH meter show a pH of 9.02, which indicates a high level of impurity

Fig. 4: Acetone reclamation readings in the pH meter show a pH of 6.86, indicating a high purity level.

RESULTS

The results were tabulated using descriptive statistics, as shown in Table 1. The acetone was graded into 3 categories based on purity. Table 2 depicts that from 150 litres of impure acetone, 85.3% of acetone reclamation was achieved with a purity of 98.60% - 99%.

Table 1: Shows the different grades of acetone based on the purity.

Acetone	Purity		Amount (litres)
	pH	%	
Grade I	8.47	79%	50
Grade II	7.98	86%	50
Grade III	7.35	95%	50

Table 2: Shows the purity and amount of acetone after reclamation.

Acetone	Purity after reclamation		Acetone reclamation	
	pH	%	litres	%
Grade I	6.83	97.60%	39	78%
Grade II	6.91	98.80%	42	84%
Grade III	6.95	99.30%	47	94%

DISCUSSION

In this study of acetone reclamation, 150 litres of acetone with varying purity grades were used. Grades I, II, and III had purity levels of 79%, 86%, and 95%, respectively, as shown in Figure 1 and Table 2. Although earlier researchers had developed standardized techniques for efficient acetone distillation, such as freeze separation, molecular sieve extraction, and vacuum distillation, these are expensive and hazardous for the skin and mucous membranes [16, 17]. According to Weast (1973), acetone recycled using vacuum distillation can have a purity of 94–98%, but acetone recycled through distillation can have a purity of 98–99% [18]. This study used a simple, cost-effective distillation approach to perform laboratory-based acetone reclamation. Heat-resistant glass jar – (a) consisted of impure acetone, which was boiled using a thermostat-controlled water bath between 55^0 – 60^0C. The acetone vapor was passed through the stainless steel tube to the cooling chamber, leaving the water, lipids, and other debris behind. The vapor was then cooled to liquid by condensation and passed to jar – (b) as pure acetone, the purity of which was assessed using the electrode pH meter. Among the three grades of acetone reclamation, grade I was 97.60%, grade II was 98.80%, and grade III was 99.30%, as shown in Figure 1 and Table 2.

Our plastination laboratory has been using this technique to recover impure acetone for the past two years, and it has proven to be highly effective. Every cycle yielded around 75–85% of the total acetone with a purity of almost 99%. Each cycle took 45 to 60 minutes for 1 liter of acetone reclamation, and each day, around 6 to 8 liters of impure acetone were recycled. With this acetone reclamation setup, 150 liters of impure acetone were recycled, and 128 liters of acetone with a purity of 97% - 99.3% was recovered. Because of this, the plastination process became more efficient and affordable. This method concurred with Weast, obtaining 99% of acetone reclamation.

Roark (1992) suggested that a distillation system with enough theoretical plates is required to recycle acetone due to the conversion of formalin to paraformaldehyde from impure acetone [19]. These problems were not faced in this unit of acetone reclamation as it employed the distillation process, in which the impure acetone was

boiled at 56^{0}C, and the vapours were condensed to pure acetone [20, 21].

However, this process was much simpler, rapid, cost-effective and relatively safe since it was done in a lab with good ventilation.

CONCLUSION

Dehydration of the tissue with acetone is one of the critical phases of the plastination procedure, and much acetone is utilised in this step. The current study demonstrates the role of acetone reclamation in the efficient and cost-effective plastination process. The amount of acetone that needs to be purchased has significantly reduced because of this reclamation from impure acetone. The current study also suggests installing a cost-effective acetone reclamation unit at plastination labs to avoid disposing of the impure acetone as toxic waste, thus preventing it from harming the environment.

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Author Contributions

All authors contributed to conducting research, writing the manuscript, statistical analysis, and proofreading.

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