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The Effects of Deinking Offset Printed Newsprint with Acetone and Perchloroethylene

Steven D. Schultz
Western Michigan University

THE EFFECTS OF DEINKING OFFSET PRINTED NEWSPRINT WITH ACETONE AND PERCHLOROETHYLENE

by

Steven D. Schultz

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ABSTRACT

The possibility of deinking newsprint with organic solvents, acetone and perchloroethylene, were examined by varying solvent mixtures, temperature of extractions, number of extractions, and consistency of extractions. Promising results were obtained in finding optimum conditions for the variables above. Yields obtained were over 94%. Solvents were recovered by distillation.

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INTRODUCTION

The objectives of this study were to determine and evaluate the effects of "dry" organic solvents, acetone and perchloroethylene, in the extraction of offset printed ink on newsprint. These solvents were chosen because of promising results in previous laboratory studies.

Theoretically since most ink vehicles are oil and resin based, they are at least partially soluble in organic solvents.

The specificity of newsprint used was determined by choosing the Western Herald which is printed with offset presses. Stock used in the extractions were all from the same printing dates to keep the amount of printing ink and stock specifications constant. Previous laboratory studies have shown very little efficiency in the removal of ink from newsprint using letterpress printing. The Western Herald was chosen because printing trends have been toward the offset process.

Variables in the extractions were temperature, number of extractions, and the consistency of the extractions. Each extraction variable was done using 100% acetone, 100% perchloroethylene, and a 50/50 mixture of the two solvents.

Evaluations were made on the deinked stock by determining yield and brightness with a G.E. Brightness meter.

BACKGROUND

The use of organic solvents in the deinking and recycling of paper is not a new idea. However little has been done in this area in the past because it was economically impractical. With the increases of todays pulp prices and the ever increasing restrictions on pollution, "dry" organic solvent deinking should again be considered.

As early as the 1930's a process for deinking with an aqueous emulsion of chlorinated hydrocarbons was developed.[1] At the Tappi Deinking Conference in 1959, "A Dry Process for Deinking" was discussed.[2] This study was prompted by the industries desire to eliminate sludge problems while removing sticky contaminants from waste paper. A side wall muller equipped with an air circulation system for cooling was used. The conclusions reported were: (1) A means of dry defibering of all types of waste papers without damage to fibers with low power requirements was acheived; (2) Major share of ultimate shrinkage separated in dry form; (3) Removal of pressure sensitive tape, rubber book bindings, hot melt bindings, etc., in every case; (4) Wax separated from milk cartons enabling fiber to be used in conventional paper; (5) Entire process accomplished without steam or chemicals.

In the early 1960's Petrolite Corporation did studies on the use of certain solvents in deinking which led to a number of patents.[4] Studies also have been done which proved that certain organic solvents would remove resinous materials from

paper.

One of the most recent developements utilizing a non-flammable solvent to remove various plastic coatings was published in 1969.[7] This process utilizes trichloroethylene to dissolve various plastic coatings such as polyethylene, polyvinylchloride, polypropylene, and wax from paper and board. The process involves multiple batch washes in a pressurized rotary reactor. Contaminated solvents used in the washing operation were distilled for purification of the trichloroethylene for reuse as clean solvent. Abrasive effects were obtained by adding diatomaceous earth with the waste paper. Advantages concluded were as follows: (1) Recovered fiber is in the same form as when it entered the reactor; (2) Treatment at high temperatures softened wet strength resins, resulting in more efficient removal of the coating; (3) Highly efficient in removing plastic and wax; (4) Closed system, no pollution; (5) Coated waste can be mixed without discrimination; (6) Solvent extraction simultaneously removes ink with coating; (7) No fiber strength loss.

The Riverside Paper Corporation at Appleton, Wisconsin, has been commercially using hot trichloroethylene to remove wax and polyethylene coatings from bleached waste cupstock and board for a number of years. They utilize 3 successive hot solvent washes at approximately 15% consistency. The washes are done in large rotating drums. Steam is used to strip residual solvent from the paper which is then conveyed directly to a repulper. The entire cycle is completed in less than 3 hours.

They are able to recover over 99% of the solvent used by distillation. Riverside processes 35 ton/day. Processing costs of a 50 ton/day mill similar to Riverside's have been estimated at slightly over $30/ton of waste paper.

Recent laboratory studies directed by Mr. Lyman Aldrich, Paper Science Department WMU, have drawn some valid conclusions in the use of organic solvents in deinking various types of waste paper.[10] At first it was thought that mechanical action similar to aqueous deinking was needed. This was not the case as a very high amount of power was required to break the fiber to fiber hydrogen bonds. Because of this being a "dry" process no water is involved which is needed to break those bonds. Also a large amount of solvent was needed. Further investigations led to the conclusion that solvent deinking is a surface cleaning operation and therefore a rubbing action was desired. This led to the design of a special wooden container made to hold a one-quart glass jar which could be shaken in a commercial paint shaker. This proved quite satisfactory and was used for my extractions as well. Studies concluded that solvent deinking was very effective on heavy coated papers printed by offset and rotogravure. They were not very effective on most light uncoated papers printed by letterpress. Yields of over 90% were achieved.

EXPERIMENTAL PROCEDURE

Reagents

1. Acetone
2. Perchloroethylene

Equipment

1. Paint shaker equipped with wooden box to hold a one-quart glass jar.
2. Glass jar and lid
3. Kitchen blender
4. Triple beam balance
5. Buchner funnel and filter paper
6. 500 ml graduated cylinder
7. Distillation equipment
8. Oven for drying and determining yields
9. Laboratory wet press
10. G.E. Brightness meter

Procedure

The paper stock (Western Herald) was cut or torn into pieces approximately one inch square to facilitate a rubbing action and dried at 105°C so that yields could be determined after deinking. The oven dry stock was weighed on a triple beam balance according to the consistency wanted for each trial. This stock was placed into a one-quart glass jar with 500 ml of fresh solvent and a lid was placed tightly on the

jar. The jar was locked into a wooden box designed by Mr. Lyman Aldrich and locked in place on the paint shaker. After each shaking period the contaminated solvent was drained off and 450 ml of fresh solvent was added due to some solvent remaining with the paper. The paper was recovered and air dried under room atmosphere overnight to remove most of the residual solvent. This air dried stock was disintegrated in a kitchen blender at high speed for 30 seconds and washed on a Buchner funnel with three liters of tap water. The washed pulp was oven dried and yields were determined.

After determining yields 3 grams of deinked stock was disintegrated in a kitchen blender for 20 seconds and filtered on a Buchner funnel. The sheet made from this was pressed once on the laboratory wet press and air dried. The dried sheets were tested for brightness on a G.E. Brightness meter and the data obtained is shown in the data table.

The following variables were investigated using 100% acetone, 100% perchloroethylene, and a 50/50 mixture of the two. A trial was run for each solvent mixture. Fresh solvent was used for each extraction stage.

Conditions for Variable I - Solvent used

1. Three extraction stages, 10 minutes shaking time for each stage
2. Extractions done at room temperature (70°F)
3. 5% Consistency (25 grams OD paper)

The above conditions were used for the following extractions except for the stated variable.

Variable II - Temperature level

A. Trial run at 90°F

B. Trial run at 110°F

The glass jar was preheated and the solvent heated 2-4°F above the proposed temperature. Heat loss after each extraction was only about 5°F due to the good insulation properties of the wooden container.

Variable III - Number of Extraction Stages

A. Trial run using single stage extraction for 30 minutes

B. Trial run using two stage extraction, 20 minutes for the first stage and 10 minutes for the second

Variable IV - Consistency of Extraction

A. Trial run at 7% consistency (35 grams OD paper)

B. Trial run at 10% consistency (50 grams OD paper)

A blank was run on stock with no extractions to compare and determine the effectiveness of each trial.

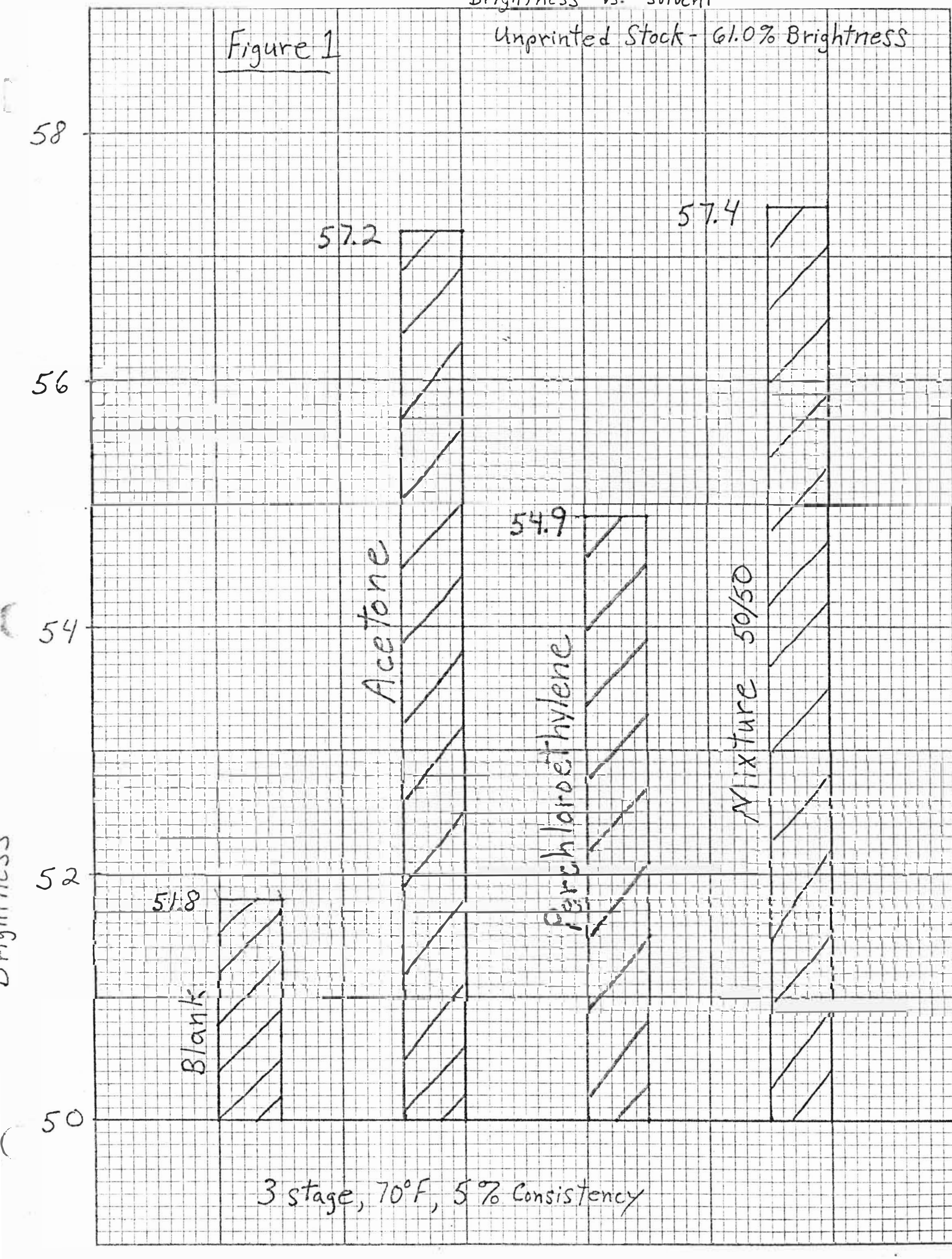
Contaminated solvents were distilled using apparatus set up by Mr. Lyman Aldrich and reruns of two arbitrary trials were made. The results obtained were within one brightness point of the first trials.

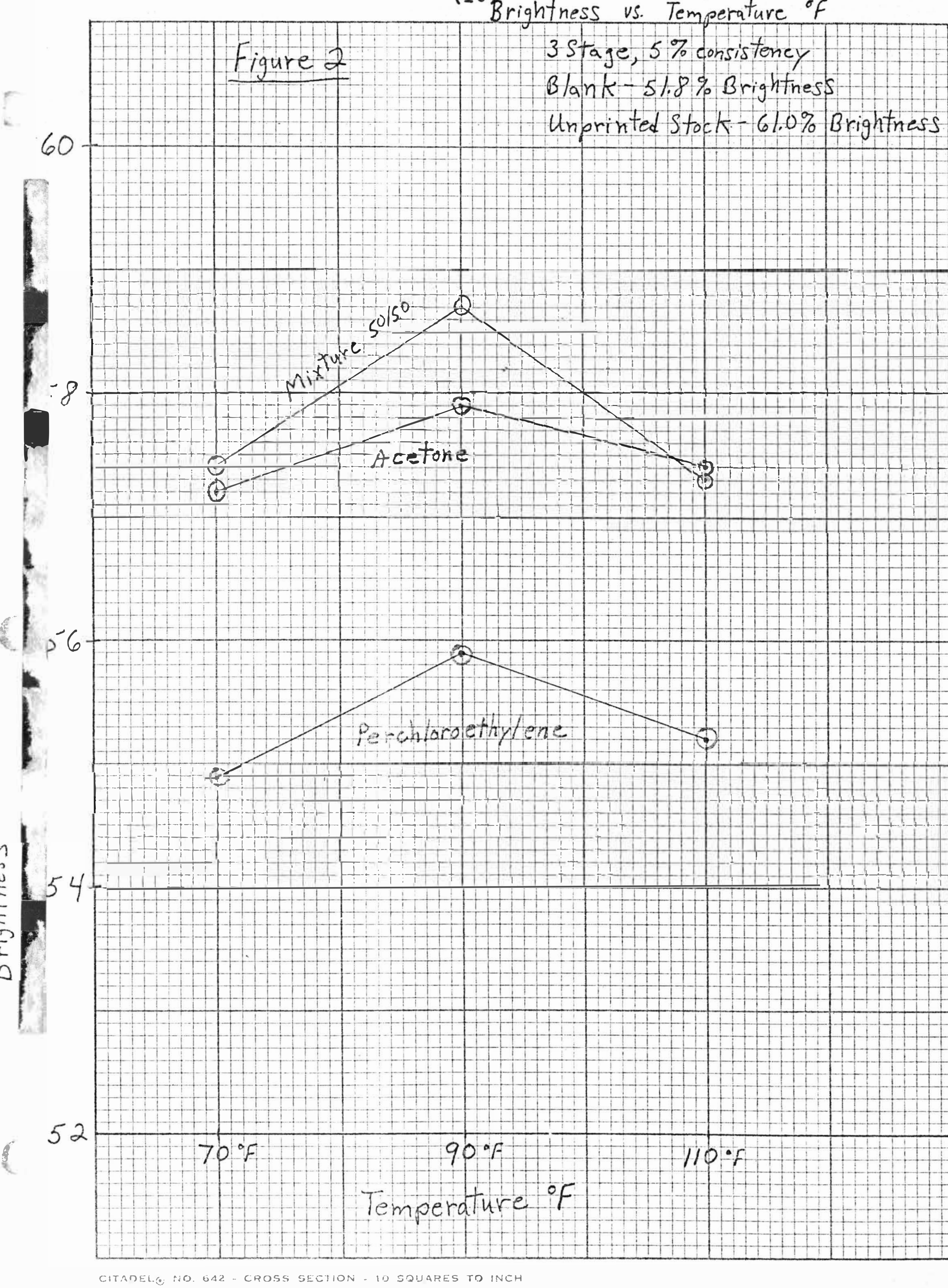
RESULTS

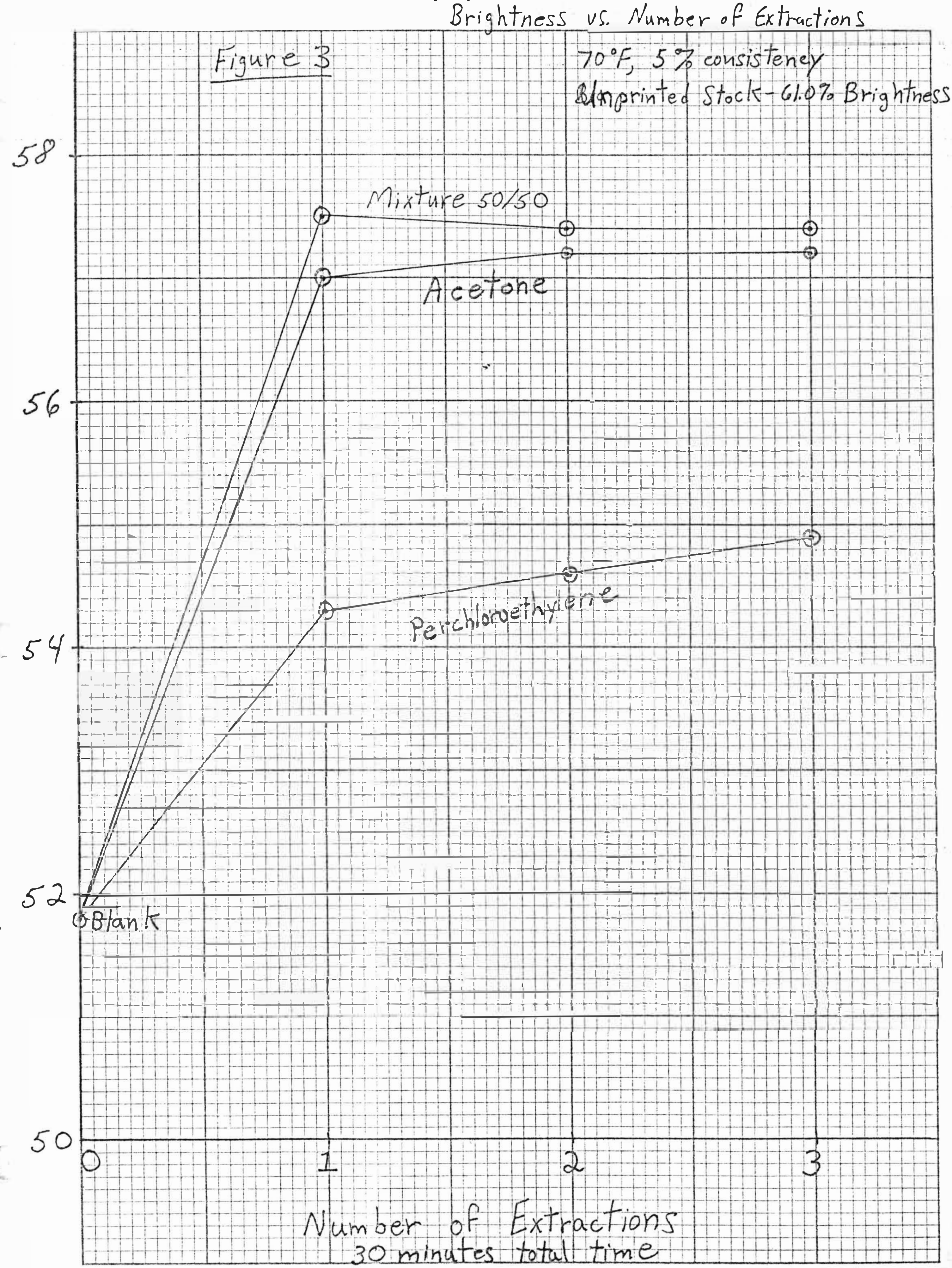
Data Table

Variable I (3 stage, $70^{o}F$, 5% cons.)	Yield	Brightness
Acetone	96.4%	57.2%
Perchloroethylene	95.6%	54.9%
50/50 Mixture	95.6%	57.4%
Variable II (3 stage, 5% cons.)		
$90^{o}F$ Acetone	96.4%	57.9%
Perchloroethylene	96.8%	55.9%
50/50 Mixture	96.6%	58.7%
$110^{o}F$ Acetone	97.2%	57.4%
Perchloroethylene	96.4%	55.2%
50/50 Mixture	97.0%	57.3%
Variable III ($70^{o}F$, 5% cons.)		
1 stage Acetone	96.4%	57.0%
Perchloroethylene	94.8%	54.3%
50/50 Mixture	95.4%	57.5%
2 stage Acetone	95.6%	57.2%
Perchloroethylene	96.0%	54.6%
50/50 Mixture	95.6%	57.4%
Variable IV (3 stage, $70^{o}F$)		
7% cons. Acetone	96.6%	58.3%
Perchloroethylene	96.0%	57.2%
50/50 Mixture	96.6%	58.8%
10% cons. Acetone	96.4%	57.5%
Perchloroethylene	96.6%	54.9%
50/50 Mixture	96.8%	56.9%
Blank	97.6%	51.8%
Unprinted Herald Stock	-----	61.0%

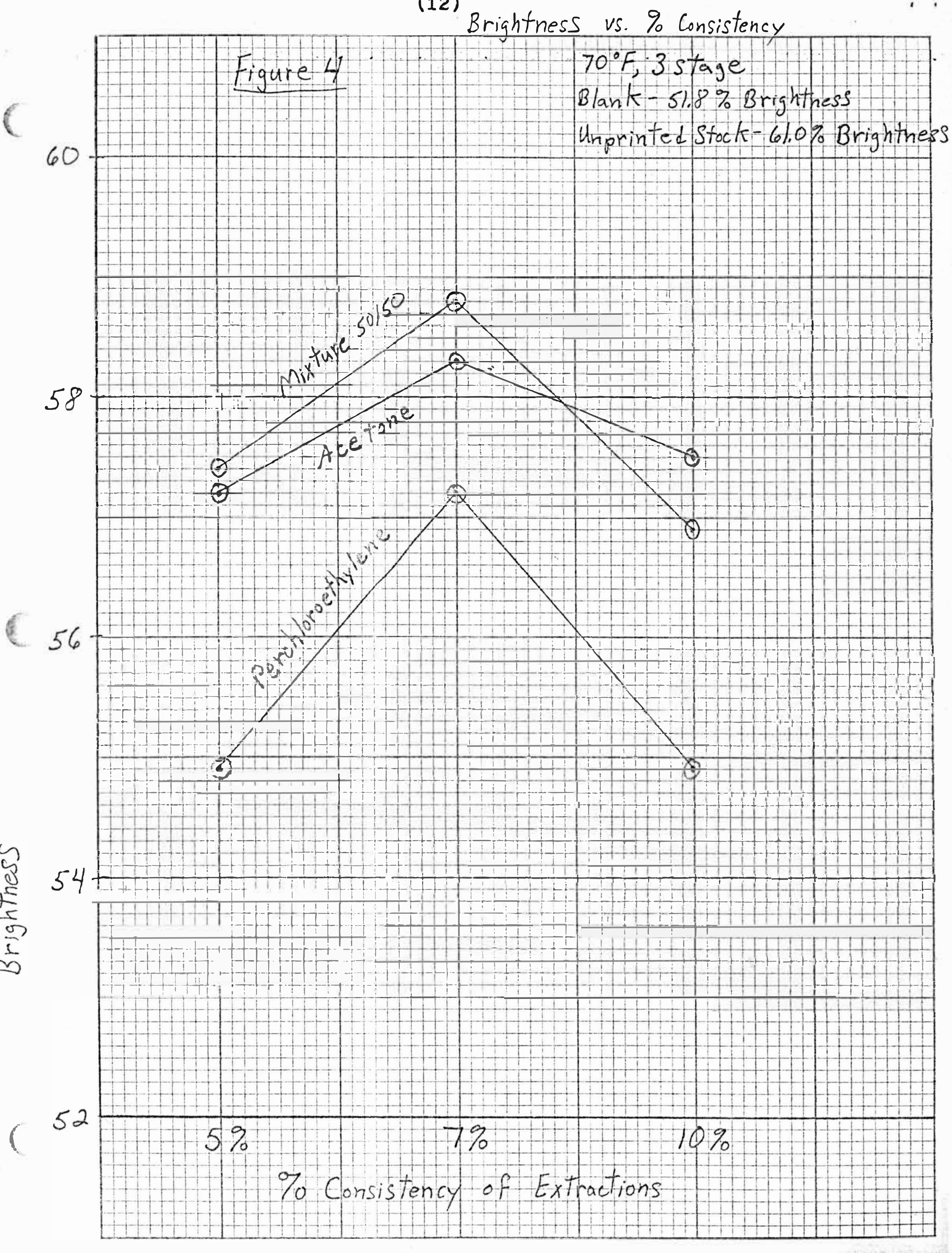
Brightness vs. Solvent




Brightness vs. Temperature °F
Figure 2
3 Stage, 5% consistency
Blank - 51.8% Brightness
Unprinted Stock - 61.0% Brightness
60
58
56
54
52
Mixture 50/50
Acetone
Perchloroethylene
70°F
90°F
110°F
Temperature °F



Brightness vs. Number of Extractions
Figure 3
70°F, 5% consistency
Unprinted Stock - 61.0% Brightness
58
56
54
52
50
Mixture 50/50
Acetone
Perchloroethylene
Blank
0
1
2
3
Number of Extractions
30 minutes total time


Brightness vs. % Consistency
Figure 4
70°F, 3 stage
Blank - 51.8 % Brightness
Unprinted Stock - 61.0% Brightness
60
58
56
54
52
Brightness
Mixture 50/50
Acetone
Perchloroethylene
5%
7%
10%
% Consistency of Extractions

DISCUSSION OF RESULTS

The most effective results in every variable were obtained with the 50/50 mixture of acetone and perchloroethylene. However as can be seen in figure 1, the 50/50 mixture often showed only a slight improvement over the extractions done with 100% acetone. Perchloroethylene alone was inferior to the 50/50 mixture and 100% acetone. With 100% perchloroethylene the unprinted areas on the extracted squares of stock were stained quite dark. The acetone appeared to keep the paper much cleaner once the ink had been removed from the surface.

Temperatures of the extractions had an effect on brightness for each of the three solvent mixtures as shown in figure 2. Best results were obtained with the 50/50 mixture at 90°F. The brightness of 58.7% achieved at this temperature was second only to that achieved with the mixture at 7% consistency. The temperature of 90°F gave the best results for each of the solvent mixtures used. At 110°F the brightness decreased to nearly that obtained at the 70°F level. I think that perhaps this could be explained by possible darkening of the groundwood at higher temperatures. Again 100% perchloroethylene gave the poorest results.

Surprisingly very small improvements in brightness were achieved by increasing the number of extraction stages (figure 3). The majority of each solvent mixtures deinking capabilities were achieved in the first or single stage. Following stages showed little or no improvements. The 50/50 mixture gave the

best results followed by the 100% acetone. The 100% perchloroethylene gave the poorest results but it did show the greatest improvement in brightness with increasing number of extractions. The 50/50 mixture showed only a slight improvement over the 100% acetone.

Figure 4 shows the effects of consistency on the deinking capabilities. For the apparatus used, best results were obtained at 7% for every trial. The highest result of the entire experiment, 58.8%, was achieved with the 50/50 mixture at 7% consistency. Brightness was about the same for the extractions done at 5% and 10% consistency. From these results it is apparent that maximum rubbing action occurs between the squares of stock at approximately 7% consistency. At 5% consistency the stock was packed too loose to achieve maximum surface rubbing and at 10% consistency there was too much stock to promote efficient rubbing action. Also the lower results obtained at 10% could have been due to the larger amount of ink.

Brightness for the blank was 51.8% so improvements were obtained for every trial. Increases in brightness with the extractions were from 2.8-7.0 brightness points.

The brightness for the unprinted newsprint of the Western Herald was approximately 61.0%. This shows that the best results achieved with the 50/50 mixture at 7% was only 2.2 brightness points from the original newsprint.

Yields obtained were all over 94%, ranging from 94.8% for the single stage extraction with 100% perchloroethylene

to 97.2% for 100% acetone at 90°F. The yield for the blank was 97.6%.

CONCLUSIONS

Deinking with acetone and perchloroethylene can be achieved with some success. The solvent mixture used, temperature of extractions, number of extractions, and consistency of extractions all have an effect on the final brightness.

Among the conditions examined the 50/50 mixture of acetone and perchloroethylene was the most effective. Because the acetone appears to be the key solvent and is cheaper than most organic solvents, extractions done with mixtures containing acetone may be feasible. However there are needs for many safety precautions when using acetone or any organic solvent.

The most efficient deinking of the Western Herald took place at 7% consistency. This proves that the optimum consistency for a given deinking vessel is one of the most important variables.

The majority of ink was removed in a single extraction so there doesn't seem to be a need for anymore than two extractions for maximum efficiency.

Best temperature examined was 90^{o}F. Higher temperatures had a tendency to decrease brightness.

The solvents were easily recovered by distillation so solvent costs would be a small portion of a solvent deinking operation.

RECOMMENDATIONS FOR FURTHER WORK

1. Deinking with different solvents and mixtures.
2. Bleaching of solvent deinked newsprint.
3. The effect of pressure on deinking newsprint.
4. Design of various solvent deinking equipment.

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