FURFURAL AS A PAINT AND VARNISH REMOVER

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INTRODUCTION

The industrial importance of furfural is of ever increasing prominence because of the ease with which it can be obtained from corn cobs, oat hulls, wood waste, and any other pentosan containing materials.

Past researches on this subject have dealt mostly with the applications of furfural as plastics. Other researches have been along related lines as furfural as a lacquer. Research on furfural as a paint and varnish remover has been carried on to a slight extent (3).

The object of this research was to check the validity of the results obtained in a previous research, "Furfural as a Paint and Varnish Remover" by Charles M. Robinson (3), and to develop a new product, if any, that would more nearly meet the demand. The complete object of this investigation as stated by Robinson is, "The objects of this investigation are to determine what is the best material, if furfural alone is not sufficient, that can be mixed with furfural to form a paint and varnish remover of good efficiency and to find in what proportions these materials should be mixed to obtain the most complete and easiest removal." The relative speed, ease and completeness of removal of identical samples of paint and varnish by a

standard paint and varnish remover and the products prepared in this investigation were also compared.

HISTORICAL

Dobereiner is credited with the discovery of furfural. He made it entirely by accident while preparing formic acid by the oxidation of sugar with sulfuric acid and manganese dioxide. He called this previously unknown product the "artificial oil of ants". It was a yellow "oil like" material. While treating corn and rye with sulfuric acid to prepare formic acid, not very long after the time of Dobereiner's discovery, Emmet obtained some of the same "oil".

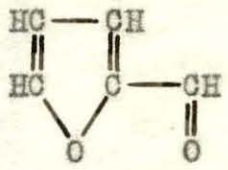
In 1840 Stenhouse obtained one ounce of this "oil" from twelve pounds of oat meal. Using this he determined the constitution of the aldehyde and some of its physical constants.

The name was changed from furfurol to furfural when the compound was discovered to be an aldehyde. The name "furfurol" was given this "oil" in 1845 by Fownes who prepared it by distilling bran with sulfuric acid.

Every year in the Middle West there are many tons of agricultural waste materials, such as: corn cobs, corn stalks, oat hulls, straw, etc., which could furnish a cheap and steady supply of furfural. One of the more interesting ideas with commercial importance at the present time is the

use of furfural as a paint and varnish remover. Pure furfural is a colorless liquid with a characteristic "empyreuamtic" odor. The technical product is yellow to brown in color. The specific gravity of furfural compared to water at 20°C. is 1.59 and its boiling point is 161.7°C., as found by the Bureau of Chemistry, at standard pressure. It does not have a harsh effect upon the skin, although it does leave a yellow stain, that and also the consideration of the fact that it is less of a fire hazard than the more volatile liquids used in common paint and varnish removers makes it especially desirable in this connection. A feature that absolutely cannot be overlooked in a paint and varnish remover is the toxicity. Furfural is not toxic.

Furfural is an aromatic aldehyde which is colorless when first prepared, but which darkens upon exposure to air and light. It is completely miscible with the common organic solvents excepting petroleum ether, gasoline, kerosene, and glycerin. The solubility of furfural in water at 20°C. is 8.3 per cent, and the solubility of water in furfural at 20°C. is 4.8 percoent. The empirical formula for furfural is $C_4H_3O.CHO$. The structural formula is



There are several methods of making furfural on a commercial basis, but there is only one in use at the present

time and that is being used by the Quaker Oats Company, Cedar Rapids, Iowa, who use the method of steam digestion of acidified oat hulls. They digest the ground oat hulls for a period of three to five hours with steam at a pressure of 60 pounds gage. They then steam distill the furfural and pass the vapors into a continous still and this delivers a product of 95 per cent purity. This is then dried and as it leaves the drier the "technical grade" furfural has a purity of 98.5 - 99.0 per cent. Refined furfuraldehyde which is drier and lighter in color is produced by vacuum distilling the technical product. The refined product soon darkens upon exposure to air and light.

EXPERIMENTAL

Materials and Equipment

The materials and equipment needed for the experimental research in connection with this problem were simple and easily obtainable. An ordinary oak floor on a small scale had previously been constructed by Robinson. The floor was constructed in the standard manner using two by fours for the foundation cross pieces, set twelve inches on centers, and sub-floor made of one by twelve inch pine boards, an oak flooring being laid on top of that in the correct manner. For the experimental work the floor was finished, as is common in the best practice, with a good grade of wood filler two coats of shellac, and two coats of hard finish varnish.

No special equipment was needed except a paint brush to apply the remover and a scraper to remove the lifted varnish.

The materials used were a standard commercial paint and varnish remover, to be used for purposes of comparison, and many substances to be mixed with the furfural that will be mentioned later.

Procedure and Observations

- During the first portion of the tests the standard method of removing the varnish as prescribed by the manufacturer of the commercial varnish remover was used. Best Cutter Paint and Varnish Remover manufactured by the Best Cutter Paint and Varnish Remover Company of Chicago, Illinois was used as the standard of comparison. However, because of the many variables that entered into this method it was altered somewhat for comparative purposes. Simultaneously, coatings of the standard paint and varnish remover and of the samples to be tested, on parallel samples of the floor, were applied. Then they were compared as to the relative time necessary for removal and for completeness of removal.

1. The first tests were made using furfural alone. This was found to remove the varnish satisfactorily, but the surface tension of the furfural was too high , and it caused the furfural to pool on the surface of the floor. Therefore the problem was to find something that would reduce the surface tension of the furfural and would also increase the ease with which it removed the varnish.

2. The second experiment tried was the use of the mixture prescribed by Robinson (3) of two thirds furfural and one third a solution of paraffin wax saturated benzene. This mixture had good varnish removing qualities, but it was not considered good by the authors because of the formation of a heavy sludge when the furfural was added

to the paraffin saturated benzene. The sludge was evidently excess wax caused to crystallize out by the furfural's lowering the solubility of wax in benzene.

3. The next experiments were concerned with finding the optimum amounts of benzene and paraffin to mix with the furfural to produce a paint and varnish remover that would meet the demands of the buying public.

The procedure was to prepare a quantity of wax saturated benzene and then to dilute portions of this with benzene to obtain various degrees of saturation.

The results of this set of tests show that for best removal a mixture of six parts of furfural with one part of a solution, containing seven-eights of a cubic centimeter of paraffin saturated benzene diluted to twenty cubic centimeters or, having a concentration of 0.0398 grams of paraffin per cubic centimeter of benzene should be used. This mixture was found to contain the most paraffin possible and yet avoid sludge formation and the least possible amount to cause the mixture to flatten properly. In comparison with the commercial remover it was approximately 85 per cent as good with regard to speed and completeness of removal.

4. After producing what was considered to be the best possible mixture containing benzene, furfural, and paraffin, the next endeavor was to find something that could be substituted for the benzene because of its inherent fire hazard and toxicity. For this study a number of emulsifying

agents were used to cut the surface tension of the furfural because the only need of the benzene was to act as a carrier for the paraffin which was insoluble in the furfural. None of these emulsifying agents gave results that were deemed worthy of further consideration. (See table I, pg. 11a.)

5. The next consideration was to investigate the possibilities of finding some other wax that could be used because of its solubility in furfural. The only "wax" found that would answer this need was a commercial product sold under the trade name of Halowax #1015. Halowax is a chlorinated naphthalene product. A saturated solution of Halowax #1015 in furfural was used, and this was rated at about 70 per cent as good as the commercial remover.

6. A suggestion of Robinson to use other substances than paraffin to cut the surface tension of the furfural was then tried. None were found that were satisfactory. Tung Oil, Soy-bean Oil, Linseed Oil, Turpentine, Castor Oil, and paraffin Oil were studied.

7. Next, there was substituted respectively, for the benzene, equal quantities of acetone, methyl alcohol, ethyl alcohol, butyl alcohol, and Skelly B. Skelly B is a gasoline fraction containimg about 95 per cent normal hexane. None of these proved as valuable because they could not compare with the benzene-furfural-paraffin mixture. Of these, however, the mixture using normal hexane was by far the best and could be rated at 80 per cent.

Table 1.

Emulsifying agents tried

Constituents added to furfural	Quality as a varnish remover
1. Lecithin, benzene, water	Lays fairly well
2. *Trigamine, benzene, water	Not a good remover
3. Ammonium Stearate	Does not lay
4. Stearic acid	Does not remove varnish
5. *Blendene	Makes a curd
6. *Glyceryl mono stearate	Thick, molasses like
7. *Wetanol	Does not lay
8. *Proflex	Unsatisfactory
9. Emulsion B	Cuts surface tension
10. *Rosoap	Not a good remover
11. Sulfonated Soy bean oil	Removes too slowly
12. *Ammonium Linolate	Makes surface sticky
13. *Turkelene	Cuts surface tension
14. *Acimal	Cuts surface tension
15. *Nelgin	Unsatisfactory
16. *Amino Stearin	Unsatisfactory

8. The use of a gasoline fraction in the above experiment led to the use of ordinary gasoline. It was found that gasoline was immiscible with furfural. However, when a small amount of gasoline was added to the benzene-furfural-paraffin mixture it mixed completely and when tested as a varnish remover it was found to improve the quality of the former product. The best proportions for the mixture were determined and were found to be one part of ordinary gasoline, five parts of furfural, and two and one-half parts of the benzene-paraffin solution used in experiment number 3, containing 0.0398 grams of paraffin per cubic centimeter of benzene. This remover could be rated at about 95 per cent.

DISCUSSION

There are seven items of importance in selecting a good paint and varnish remover:

1. Ability to penetrate within a short time.
2. Ease of removal after penetration.
3. Flattening quality (lack of globule formation).
4. Failure to discolor the wood.
5. Leaving the grain of the wood smooth.
6. Non-inflammability.
7. Non-toxicity.

The product prepared in this research meets all of these requirements more nearly than does the commercial paint and varnish remover that was used as a standard for comparison. The standard paint and varnish remover that was used was comprised of ethyl alcohol, benzene, acetone, and paraffin wax. The paraffin was present in the remover in excess, at room temperature. All of the constituents of this commercial remover are inflammable and all have relatively low flash points; and the fumes of both the ethyl alcohol and the benzene are toxic to most people.

The dark color of furfural might be considered by some to be undesirable, but the presence of color in even the darkest furfural does not act as a pigment as has been shown

by its use in various colored lacquers. It was found by Robinson (3) that the color in furfural was not absorbed by the floor, and this was also proven in this research.

It was found that even the commercial remover was not entirely satisfactory for the removal of paint. Both of the better removers found in this research were comparable with the commercial removers used, in this respect.

In the removal of samples of old paint and varnish the removers found best in this research were found to preform even better. This is believed to be caused by changes in the surface. The fresh samples of paint and varnish seem to have a rather protective surface coating that is imperviuos to the removers.

Neglecting the cost of the paraffin the cost of the constituents of the gasoline-furfural-benzene-paraffin remover would only amount to $0.68 per gallon, taking current prices as 14 cents per gallon for gasoline, 10 cents per pound for furfural, and 16 cents per gallon for benzene. This cost is well below that of the commercial remover.

Economic factors entering into the production of this paint and varnish remover show that all of the constituents will be in constant production. Furfural from agricultural wastes, benzene from coal tar or by synthetic methods, gasoline and paraffin from petroleum. These latter two products may in some years become depleted, but the gasoline can be eliminated and Halowax #1015 can be substituted for

the paraffin.

The methods of removal used in these comparative studies is not the method which should be recommended for the use of this remover. Directions for use are as follows:

Brush the remover well over the surface and continue applications and brushing until all the varnish is softened, then remove by scraping or wiping. Finally wipe the surface with a rag wetted with alcohol to remove the last traces of remover and varnish. Allow at least two hours for complete evaporation of the remover before applying a fresh coat of paint or varnish.

CONCLUSIONS

1. The effect of various ingredients to eliminate the pooling action of furfural were determined. A solution of paraffin in benzene was found to excell all others. The concentration of this solution was 0.0398 grams of paraffin per cubic centimeter of benzene.

2. Of all the mixtures prepared the one having the formula of one part of gasoline, five parts of furfural, and two and one half parts of the aforementioned benzene-paraffin solution was found to give the best results.

3. The above mixture was approximately 95 per cent as good as commercial remover, compared as to speed and completeness of removal.

4. The mixture prepared in this research could undoubtedly be produced on a large scale and sold more cheaply than the commercial removers now on the market.

SUGGESTIONS

Further work does not seem to be merited by this problem because most of the possibilities have been exhausted and any further work should be merely incidental to the marketing of the product.

SUMMARY

A paint and varnish remover was prepared having the formula of one part of gasoline, five parts of furfural, and two and one half parts of a benzene solution containing 0.0398 grams of paraffin wax per cubic centimeter of benzene. This mixture was applied to test samples of paint and varnish on an experimental floor and also to old varnish. The results indicate that the product has all of the necessary characteristics of a good paint and varnish remover.

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