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Visualization Fluids: The Search for an Inexpensive Alternative to Chlorinated Fluorocarbons

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ABSTRACT: The restrictions being placed on chlorinated fluorocarbons by the U.S. Government are driving the need to find a suitable alternative for use as a visualization fluid.

Visualization fluid is the term given to fluids that will make paper translucent with little or no damage to paper, ink, correction fluid, or photographs.

Light petroleum distillates have been the most successful visualization fluids tested to date; however, they are not as effective as chlorinated fluorocarbons, especially with permanent marker inks, carbon, paper, and NCR paper.

KEYWORDS: questioned documents, visualization fluids, chlorinated fluorocarbons

"Visualization fluids" is the term given to fluids that will make paper translucent with little or no damage to paper, ink, correction fluid or photographs. Several papers have been written on the use of chlorinated fluorocarbons (CFCs) as visualization fluids for use in examining correction fluid obliterations. Lee Waggoner mentions the use of freon in his "Examination of Correction Fluid Obliterations" [*1*], while Gaile Heath and Marvin Dawson specifically mention the use of trichlorotrifluoroethane (Freon 113) in their "Visualization Fluids" [*2*].

The restrictions being placed on CFCs by the U.S. Government are driving the need to find an alternative visualization fluid. The restrictions on CFCs are being imposed to retard the decay of the ozone layer around the earth. The production schedule that was created (Table 1) is limiting the availability of these products.

In addition, with today's requirement to do more with less, the prices of these products are becoming cost prohibitive. According to Heath and Dawson [*2*], the cost of trichlorotrifluoroethane was about $70.00 for a gallon in 1986 (about $18.50 per liter). According to the 1993 edition of the Sigma Chemical Company Catalog [*4*], trichlorotrifluoroethane sells for $71.50 for a 1 liter bottle. The 1994 Sigma Catalog [*5*] lists it at $85.65 for a 1 liter bottle (a price increase of over 450% in 8 years).

Some of the criteria used in selecting a potential visualization fluid were: (1) a fluid that would make paper translucent or transparent, (2) a fluid that would evaporate rather quickly with no residue, and (3) a fluid that would not act as a solvent to inks.

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TABLE 1—*Phase-out of production and consumption of chlorinated fluorocarbons* [3].

Date	Production Percentage
1991	85%
1992	80%
1993	75%
1994	65%
1995	50%
1996	40%
1997	15%
1998	15%
1999	15%
2000	0%

NOTE: Effective on January 1 of each year specified, it shall be unlawful for any person to produce any chlorinated fluorocarbons in an annual quantity greater than the relevant percentage specified. The percentages refer to a maximum allowable production as a percentage of the quantity of the substance produced by the person concerned in the baseline year (1990).

The following chemicals were tested as potential visualization fluids: acetone; chloroform; ethyl alcohol; hexane; isopropyl alcohol; methyl alcohol; methylene chloride; VM&P naphtha; pentane; petroleum ether; toluene.

Of the eleven, acetone, chloroform, ethyl alcohol, isopropyl alcohol, methyl alcohol, VM&P naphtha, and toluene are known ink solvents and were quickly eliminated. Methylene chloride is also a solvent, but was tested because it is sold as a "letterbomb visualizer." This left hexane, pentane, and petroleum ether as potential replacement visualization fluids for CFCs. This report examines in some detail these four candidates.

The testing procedures and results of the ink tests are given in Table 2. The data is compiled and displayed in a format similar to the Reactivity Data Section of the User's Manual for Sunmark Research Company's "Liquid Window" and "Lucid" visualization fluids [*6*]. "Liquid Window" and "Lucid" are composed of a proprietary mixture of halocarbons which, according to Sunmark, do not fall under the phase-out schedule dictated by the law referenced above. However, the price on these products may make them cost prohibitive also. According to Sunmark, the price of "Liquid Window-SA" is $231.50 per liter; the price of "Liquid Window-SP" is $373.15 per liter; and the price of "Lucid-SA" is $570.82 per liter. The light petroleum distillates (hexane, pentane, and petroleum ether) reacted the same on all of the inks. These results compared favorably with those published for "Liquid Window" and were much better than for methylene chloride, which is carcinogenic. The author has not tested "Liquid Window" or "Lucid" against the light petroleum distillates yet, but it is planned in the future. According to Sunmark's data, "Lucid-SA" has had

TABLE 2—*Reactivity data.*

Material	Color	Pentane, Hexane, & Pet Ether			Methylene Chloride		
		1 Min	5 Min	10 Min	1 Min	5 Min	10 Min
Ball Point Pen Ink							
Bic Stic	Black	0	0	0	1	2	2
Bic Stic	Blue	0	0	0	1	1	2
Bic Stic	Green	0	0	0	0	1	1
Bic Stic	Red	0	0	0	3	3	3
Itoya Gripper	Black	0	0	0	3	3	3
Itoya Gripper	Blue	0	0	0	3	3	3
Itoya Gripper	Red	0	0	0	3	3	3
PaperMate Flexgrip	Black	0	0	0	3	3	3
Pilot	Black	0	0	0	3	3	3
Pilot	Blue	0	0	0	3	3	3
Pilot	Red	0	0	0	3	3	3
Ritepoint	Black	0	0	0	1	1	1
Schwan Stabiliner	Black	0	0	0	2	2	2
Schwan Stabiliner	Blue	0	0	0	2	2	2
Schwan Stabiliner	Red	0	0	0	1	1	1
Fountain Pen Ink							
Sheaffer Skrip	Black	0	0	0	0	0	0
Rolling Ball Marker Ink							
Bic Metal Point	Black	0	0	0	0	0	0
Bic Roller	Blue	0	0	0	1	1	2
Faber-Castell Uni-Ball	Black	0	0	0	0	1	1
Faber-Castell Uni-Ball	Red	0	0	0	1	1	2
Marvy Rollerball	Red	0	0	0	0	0	0
Rolling Ball Marker Ink							
Pentel Superball	Black	0	0	0	1	1	1
Pentel Superball	Blue	0	0	0	0	0	0
Spree	Blue	0	0	0	0	0	0
Fiber-Tip Pen Ink							
Bic Office Marker	Black	0	0	0	0	1	1
Bic Office Marker	Blue	0	0	0	0	0	0
Bic Ultrafine	Black	0	0	0	0	0	0
Flair	Blue	0	0	0	0	0	0
Flair	Green	0	0	0	0	0	0
Flair	Red	0	0	0	0	0	0
Pilot Fineliner	Black	0	0	0	0	0	0
Sanford Big Sig	Blue	0	0	0	0	0	0
Sanford Expresso	Black	0	0	0	1	1	2
Sanford Expresso	Blue	0	0	0	0	0	0
USA	Red	0	0	0	0	0	0
Hi-Liter Ink							
Berol Emphasis	Yellow	0	0	0	0	0	0
Bic Briteliner	Blue	0	0	0	0	0	0
Bic Briteliner	Yellow	0	0	0	0	0	0
Carter's	Blue	0	0	0	0	0	0
Sanford Major Accent	Yellow	0	0	0	0	0	0
Stabilo Boss	Yellow	0	0	0	0	0	0
Permanent Marker Ink							
Berol	Black	0	0	0	3	3	3
Berol	Blue	0	0	0	3	3	3
Berol	Red	0	0	0	3	3	3
Eberhard Faber (E.F.) Markette	Black	1	2	2	3	3	3
E.F. Markette	Blue	2	3	3	3	3	3
E.F. Markette	Green	0	1	1	3	3	3
E.F. Markette	Red	1	1	2	3	3	3
Sanford Sharpie	Black	1	1	1	3	3	3
Sanford Sharpie	Blue	0	0	0	3	3	3
Sanford Sharpie	Green	2	2	2	2	3	3
Sanford Sharpie	Red	0	0	0	2	3	3
Sanford Sharpie	Yellow	0	0	0	2	3	3
Miscellaneous							
Marsh 88 Paint Marker	White	0	0	0	0	0	0
Sanford Stamp Pad Ink	Red	0	0	0	0	0	0
Pitney Bowes Postage Meter Ink	Red	0	0	0	0	0	0

no observable effect on any material tested, including the full immersion of cigarettes [6]. Some other tests that were done with pentane include newspaper ink, safety paper, postage stamps, typewriting, address labels, Higgins Waterproof Black India Drawing Ink, and various types of paper. All of these items were immersed for 15 minutes or longer with no adverse effects.

Because these light petroleum distillates evaporate so fast, it is recommended that the paper or envelope in question be placed in a large zip-loc bag. Pour the chemical in the bag and try to remove as much of the air as possible before sealing the bag. The visualized material may be examined or photographed through the zip-loc bag. The material should not be exposed to any chemical longer than necessary, as prolonged exposure may have some adverse effects on the ink(s), paper(s), correction fluids, etc. These light petroleum distillates are extremely flammable and should be kept away from heat, sparks, and flame. They should also be used in an area with adequate ventilation.

The Latent Print section at the Mississippi Crime Laboratory presented one case to be tested. An anonymous letter consisting of newspaper print and photos on a sheet of notebook paper was submitted for examination. The newsprint was placed on the paper with cellophane tape. A reverse image of a latent print was clearly present under one piece of tape. The analyst wondered if the paper could be made transparent enough to view the latent print, rather than go through the usual method of photographing the latent print and then reversing the negative. In order to test this idea, a fingerprint was placed on the sticky side of a piece of cellophane tape, and then the tape was placed on a sheet of plain photocopier paper. The sheet of paper was placed in a zip-loc bag with about 50 milliliters of pentane. The latent print under the tape could be seen through the paper, but not with enough ridge detail for the analyst to conduct his examination. The pentane did not affect the latent print, but after about ten minutes, the cellophane separated from the adhesive and the latent print. Once the paper was dried, the cellophane could be placed back over the adhesive.

The question was also raised about whether latent prints on paper would be affected by immersion in one of these visualization fluids. Two sheets of white photocopier paper were used. One was used as a control and the other as the test sheet. Latent prints were placed on both sheets in relatively the same locations. The test sheet was then immersed in pentane for approximately 15 minutes. After the sheet was removed from the pentane and allowed to dry, it was treated, along with the control sheet with a ninhydrin solution. The latent prints on both sheets of paper developed quite well, with no difference in quality between the control sheet and the test sheet.

A limited test on the effect of visualization fluids on paper with known indentations was done using three different types of paper (25% rag, photocopier, and notebook). The indentations were clearly visible using oblique lighting and had been successfully developed on the ESDA prior to immersion. However, after immersion, the indentations were not developed by the ESDA for any of the types of paper.

None of the alternate visualization fluids tested were kind to NCR paper. All of the fluids left a stain on the paper, regardless of whether it was a coated back, coated front/coated back, or coated front sheet. The dye on carbon paper also ran and left an inky mixture with all of the fluids tested.

All of the light petroleum distillates performed equally well as visualization fluids. With the exception of some of the permanent marker inks and the NCR and carbon papers, they did not damage any of the items tested. Of the three, pentane is the most volatile and evaporates the quickest. The cost of pentane is also quite reasonable. According to the Sigma Chemical Company Catalogs [4,5], pentane was priced at $26.20 per liter in 1993, and is priced at $23.60 during 1994. Because of this, it is recommended at this point as the most inexpensive visualization fluid to replace CFCs.

Reactivity Data Section

The testing procedures and results are based on the full immersion of the materials and are shown in Table 2. The effects of each of the visualization fluids on the specified materials for the time periods indicated are presented. Results may vary depending on the method used to apply the fluids and other factors.

The paper used for the ink evaluations was Classic Natural White, 25% Cotton Fiber, Classic Linen (Stock #05202). The envelopes used for the postage ink evaluation was Beckett Paper, 25% Cotton Fiber, Concept Linen (Stock #444311). The inks were allowed to dry for between 3 to 8 hours. The fluid and air temperature was between about 74 to 78°F. Each of the tested materials was fully immersed in each of the fluids for the time periods indicated in the table, then permitted to dry before being compared against unimmersed controls. The ratings given were based on examinations of the treated materials being made, without magnification, under an incandescent bulb, daylight, and long-wave ultraviolet light. The fluids used in each test were also examined for signs of discoloration, clouding, or contamination by fluorescent agents.

A "0" indicates no observable interaction or damage; a "1" indicates slight interaction, as slight bleeding or subtle color or hue changes; a "2" indicates moderate interaction, readily noticeable as bleeding, blotting, running or color alteration; a "3" indicates gross interaction, such as very substantial bleeding or running, usually resulting in discoloration of the fluid or a marked color change.

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