

THE COMPOUNDING OF "CORDO SOLUTION" FOR PROSTHETIC APPLICATIONS

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INTRODUCTION

The Spring 1970 issue of this Bulletin contained an article entitled "Polyvinyl Chloride (Cordo) Facial and Body Prostheses." It described how "Cordo Solutions" were developed through a cooperative effort between the VAPC Restorations Laboratory and industry.

A number of inquiries have been received from interested readers requesting further information on the use of "Cordo Solutions." This article describes easily performed variations in the compounding of "Cordo Solutions" for prosthetic applications.

THE BASIS FOR "CORDO SOLUTION" COATINGS

As indicated by the chemical reaction chart in Figure 1, acetylene gas reacting with dry hydrogen chloride produces vinyl chloride, and acetylene gas passing through acetic acid forms vinyl acetate. When vinyl acetate and vinyl chloride are combined by copolymerization, polyvinyl chloride acetate resin is produced. This is the basic resin type utilized in compounding "Cordo Solution" Coatings.

PROPERTIES

At the time of compounding "Cordo Solution Plain," its properties can be varied by regulating the solvent content of the solution mixture. This is brought about by the use of a solvent thinner or extender called Cordobond Thinner P-371. The VAPC Restorations Laboratory incorporates the Cordobond Thinner into the basic Cordobond resin according to the requirements of the various "Cordo Solutions."

Cordobond Thinner P-371 is composed primarily of Ketones with low boiling points. The evaporation of the Ketones from "Cordo Solution" Coatings leaves a coated resin surface that is tough, flexible, and chemically resistant.

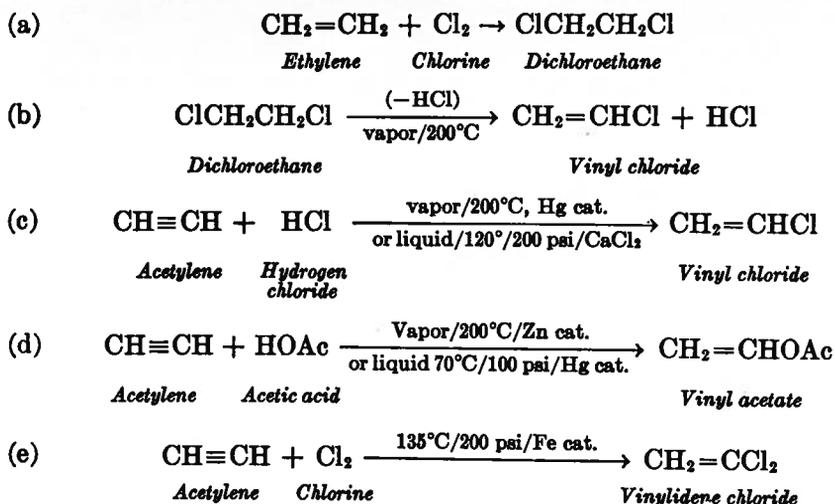


FIGURE I.—Chemical equations show how vinyl chloride and vinyl acetate are made. Reacted together they make polyvinyl acetate resin from which "Cordo Solution Plain" is made.

ADDITIONAL INGREDIENTS

To compound "Cordo Solutions" properly for use in the fabrication of facial or body prostheses, it is necessary to fortify the resulting solutions with certain ingredients other than solvents alone.

The addition of Stabilizer #21 to basic "Cordo Solution Plain" maintains the properties of the materials throughout the processing period and retards deterioration of the finished product when exposed to ordinary heat, light, and oxidation.

When compounding, polymeric, nonmigratory plasticizer Paraplex G-50 is intentionally omitted from basic "Cordo Solution Plain" but is added when compounding all other "Cordo Solutions" made from basic "Cordo Solution Plain."

The materials, source of materials, and equipment used to compound "Cordo Solutions" are listed in Tables 1 and 2.

BASIC "CORDO SOLUTION PLAIN"

"Cordo Solution Plain," compounded by the technique shown in this article, is particularly useful in producing a tough skin-like surface texture with a flexible-type prosthesis. The tough "case-hardened" effect is brought about by purposely omitting plasticizer from the compounding of "Cordo Solution Plain." This solution is generally applied in two to four coats to the mold surfaces, and depends on whether the coating is to be accomplished by slush molding or by brush. Brushing tends to

TABLE 1.—*Materials and Sources of Materials for Making "Cordo Solution" PVC*

Material	Source
Cordobond* P-315-B2	Ferro Corporation Composites Division 34 Smith Street Norwalk, Conn. 06852
Cordobond* Thinner P-371	
Paraplex G-50 Plasticizer	Rohm and Haas Co. Resinous Products Div. Philadelphia, Pa. 19105
Stabilizer #21	Stauffer Chemical Corp. Specialty Chemical Div. 299 Park Ave. New York, N.Y. 10017
Marshall Oil Photo Colors—Tubes	John G. Marshall Mfg. Co. 167 North 9th St. Brooklyn, N.Y. 11211
Alizarin Red Winsor Newton Oil Color	Any artists' supply store

* Registered trademark of the Ferro Corporation.

TABLE 2.—*Equipment Used to Compound "Cordo Solution"*

Type	Description or Use	Quantity
Jars	1-gal. clear glass wide-mouth, with screw-type lids	Elective
Stirring paddle	Wood, approximately 14"—18" long, 1" wide and ½" thick	2
Oven	Drying, for 70°C. temperature	1
Thermometer	Centigrade	1
Scale, weighing	Gm. or oz.	1
Red crayon	Or marking Pencil	1
Clock or timer		1
Measuring graduate	For measuring stabilizer and plasticizer, gm. or oz.	1

thin out the coating while being applied. All "Cordo Solutions" pour readily due to their low viscosity (see Fig. 2).

Referring to Table 3, Cordobond P-315-B2 and Cordobond Thinner P-371 are highly volatile, flammable substances of organic chemical origin. The prevention of endangerment to health by inhalation requires that all such materials must be kept tightly covered when not in use and must at all times be handled in a well-ventilated area. Also, smoking and open flames cannot be tolerated in the work area where these materials are uncovered or otherwise in use.



FIGURE 2.—Note light pour consistency of "Cordo Solution" for slush molding. Same consistency is used for brushing "Cordo Solution" to stone or metal molds.

TABLE 3.—*Finished Formula for "Cordo Solutions" Developed by the Restorations Laboratory, VA Prosthetics Center*

Elements	Quantity ^a	
	Gm.	Oz.
Cordobond P-315-B2 clear solution base	2760	975
Paraplex G-50 ^b	300	10.5
Cordobond Thinner P-371	1000	35
Stabilizer #21	40	1.4
Coloring-Marshall oil photo colors (tubes)	as needed	as needed
Winsor Newton Oil-Alizarin Red (tube)	as needed	as needed

^a The quantities shown are sufficient to make 1 gal. of clear "Cordo Solution Plain."

^b Paraplex G-50 plasticizer is used only when making "Cordo Solution 50."

The industry that formulates and supplies the clear solution base resin ships the resin in 5 gal. steel drums tightly closed by a well-clamped lid. In formulating the basic gelatinous vinyl resin, the supplier starts off the compounding for the customer by the addition of some small amount of solvent.

"Cordo Solution Plain" is further compounded as follows:

1. Select and prepare an adequate bench space in a well-ventilated area of the laboratory.
2. Position scale for weighing procedures.
3. Place drum container of Cordobond P-315-B2 clear solution base material near scale.
4. For each gallon of "Cordo Solution" to be compounded place an equal quantity of 1-gal. clear, wide-mouth glass jars in close prox-

imity to other required materials and equipment. (The Restorations Laboratory orders Cordobond P-315-B2 clear solution base material in 5 gal. quantities from the supplier and routinely mixes 5 gal. or multiples of 5 gal. at a time.)

5. Place a 1-gal. jar on scale and set scale to zero.
6. Make certain no open flame is near; remove cover from drum container of Cordobond base material.
7. Referring to Table 3, transfer the required amount, by weight, of Cordobond base material from drum container to the 1-gal. jar on scale (Fig. 3).
8. With the proper amount of material placed in the jar, mark level in crayon on outside of jar. Marking the jar as each ingredient is added can eliminate all repetitious weighing procedures when duplicating the procedure in the future.
9. From Table 3, measure the quantity of Cordobond Thinner P-371 and add to the jar containing Cordobond base material. Mark level of the two required quantities on outside of jar (this will eliminate the weighing procedure of all future materials which can then be poured directly from the can as shown in Figure 4.)



FIGURE 3.—Cordobond base material being transferred from container to 1 gal. jar for mixing with Cordo thinner.



FIGURE 4.—Cordobond thinner being poured into jar containing Cordobond bulk material prior to mixing.

10. Place jars containing Cordobond base material and Cordobond thinner into a warming oven or water bath as shown in Figure 5. (Explosion-proof electrical circuitry should be in evidence in the

entire work area.) Place jar covers loosely in position on the jar top during the heating procedure. The temperature of the oven should be regulated to 70 deg. C., and the mixture should be warmed at 70 deg. C. for 3 hours before carefully stirring with the wooden paddle.

11. Continue heating and after 1 hour carefully stir again until mixture is completely blended.
12. Turn off oven.
13. Allow warmly blended "Cordo Solution" to remain in the oven until it has cooled to room temperature.
14. From Table 3, measure the quantity of Stabilizer #21 required for each 1-gal. jar of "Cordo Solution" being compounded; add stabilizer to the cooled solution by slowly, carefully stirring until smooth (Fig. 6).

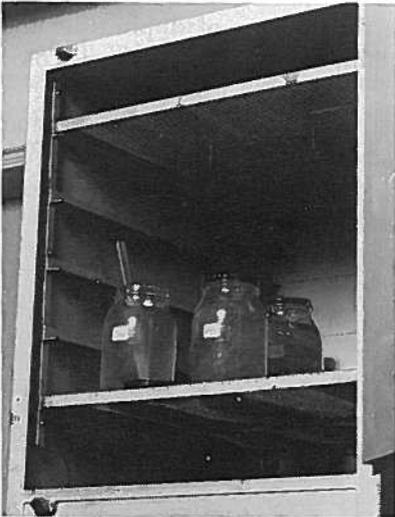


FIGURE 5.—Heating-oven method for receiving 1 gal. jars of "Cordo Solution Plain" for warming at 70 deg. C.

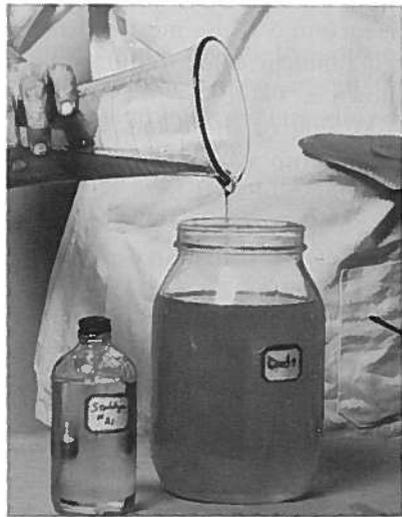


FIGURE 6.—"Cordo Solution Plain" receiving measured quantity of Stabilizer #21.

CONTROL OF FLEXIBILITY

All special "Cordo Solutions" are compounded from the original "Cordo Solution Plain," in 1 gal. quantities, which contains a low percentage of plasticizer. Plasticizer is added in various amounts to control the properties of "Cordo Solutions" for flexibility. Clear "Cordo Solution 50" contains "Cordo Solution Plain" with 300 gm. of Paraplex G-50 carefully stirred into the solution until smooth. "Clear Cordo Solution Half and Half" contains "Cordo Solution Plain" with 150 gm. of Para-

plex G-50 added. Clear "Cordo Solution Soft" contains "Cordo Solution Plain" with 450 gm. of Paraplex G-50 added. The various amounts of plasticizer affect the degree of softness required of the completed prosthesis. Too extensive use of plasticizer can weaken the final molded product. To introduce plasticizer into "Cordo Solution" properly, the plasticizer is carefully measured in the quantity shown in Table 3 or in the other quantities stated above.

PIGMENTING "CORDO SOLUTION 50"

Photographic colors, because of their translucency, are used for the most part in pigmenting "Cordo Solution" to resemble natural flesh tones. The basic or intrinsic color is kept light, due to an external tinting procedures required to follow for final completion of a prosthesis.

The one exception to the use of photographic colors is in the substitution of Winsor Newton Alizarin Red, which is less translucent and has been found to be most satisfactory for the purpose of duplicating the red tones of color found in natural flesh. This is an artist's oil color shown in Table 3.

Mixing of the colors is accomplished by pouring "Cordo Solution Plain" into a "Cordo Solution 50" solution jar to the level marked by a line established by a previous measurement. Color ingredients from Table 4 are then added and slowly stirred into solution until they become evenly distributed.

TABLE 4.—Internal Colorant for "Cordo Solution 50"

Elements	Quantity	
	Caucasian	Negroid
"Cordo Solution 50"	1 gal.	1 gal.
White	60 cc.	60 cc.
Raw Sienna	1½ full medicine droppers	5 full medicine droppers
Khaki	1½ full medicine droppers	—
Burnt Umber	—	5 full medicine droppers
Alizarin Red	40 drops	10 drops
Black	4 drops	—

SOME APPLICATIONS OF "CORDO SOLUTIONS"

Slush Molding Cosmetic Gloves

"Cordo Solutions" have been utilized extensively at the VAPC Restorations Laboratory for the purpose of slush-mold casting of cosmetic gloves. This is accomplished by the use of latex molds taken from donors. Ten to twelve coats are carefully applied, depending on the thickness required, allowing a minimum of ½ hour drying time between coats.

The partial hand requires a softer, more pliable glove so that certain changes are required in the plasticity of the various coats of "Cordo Solutions" used (Table 5).

TABLE 5.—Coatings of "Cordo Solutions" Required for Two Types of Cosmetic Gloves and Their Order of Applications

Type of "Cordo Solution"	No. of coats	
	Full hand	Partial hand
Plain (clear)	2	2
Half and Half	2	2
50	2	2
50 (pigmented)	3	none
Plain (clear)	3	none
Soft (pigmented)	none	3
Soft (clear)	none	3
Total no. of coats	12	12

Slush molding is the process of forming hollow shapes by pouring resin into a female mold to produce a shell, and then pouring out the excess and allowing the remainder to dry. A complete cosmetic glove is shown being fabricated by this molding technique in Figure 7.

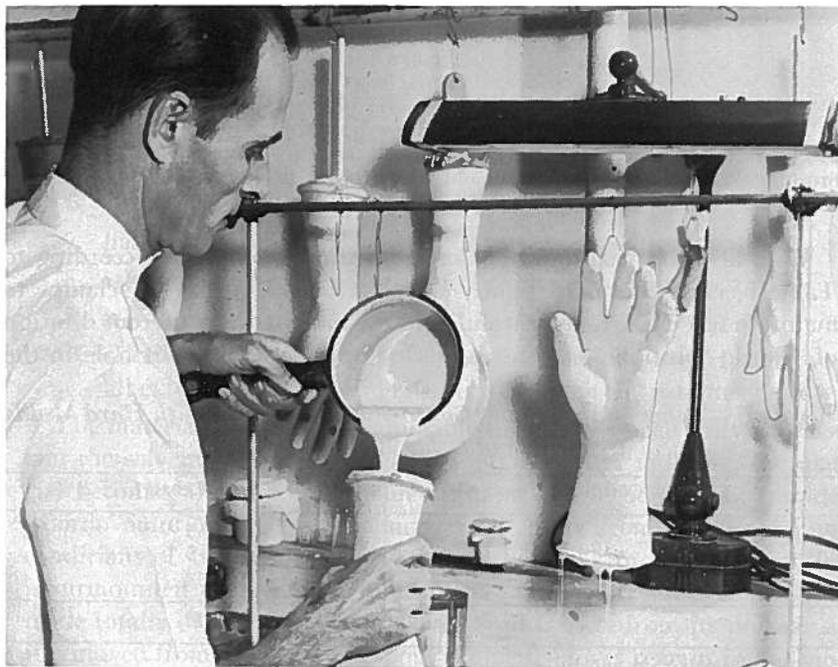


FIGURE 7.—"Cordo Solution 50" poured into female mold, then excess poured out and mold hung on stand in inverted position to drain and dry.

Brush Molding Facial and Body Prostheses

The molds used for facial and other body prostheses are in direct contrast to the soft flexible latex ones used for making cosmetic gloves. Facial molds are routinely made from a variety of hard materials such as artificial stone, sprayed metal, or composite metals (preferably aluminum) and epoxy.

The first steps in preparation for molding a prosthesis is to brush-coat such molds with coatings of "Cordo Solution" by using a soft sable brush. The "Cordo Solution" is painted on the mold surfaces in thin coats, being careful to keep the lands (edges) of the mold free from any of the coating material. This is to permit the mold to close evenly without obstruction. Each "Cordo Solution" coating is allowed to air dry at least 1/2 hour before the next coat is applied to the mold (Fig. 8 and 9).



FIGURE 8.—Equipment and materials for brushing "Cordo Solution" onto mold surfaces.



FIGURE 9.—"Cordo Solution 50 (pigmented)" being applied to surfaces of metal mold.

With all brush coatings of "Cordo Solution" completed according to Table 6, close the mold tightly with masking tape or "C" clamps to maintain full closure, and carefully fill the mold with 50 percent dilution of "Cordo Solution 50." This is carried by way of the pour hole in the

TABLE 6.—Types and Coats of "Cordo Solutions" Used with Hard Molds in Facial and Other Body Prostheses

Type of "Cordo Solution"	No. of coats ^a
Plain (clear)	4
50 ^b	5
50	4
Total no. of coats	13

^a Apply all coats thin and tinted.

^b After these applications, place sheer nylon stocking material for strengthening on coated surfaces before applying the final coats of "Cordo Solution 50."

mold which is made during the mold-making procedure. The mold is then emptied making certain the vent and pour holes remain open, allowing the mold to dry 48 hours with the vent holes positioned downward. This amount of time is required for air drying because of the small entrance to the internal area of the mold.

The prepared mold is then filled with a low fusing plastisol for oven curing up to 125 deg. C. for 1 to 2 hours, depending on the size and thickness of the mold. Such molds are cooled thoroughly in the oven before opening.

DISCUSSION

The applications of "Cordo Solutions" described in this paper appear to be the most useful yet devised for flexible prosthetic restoration of maxillofacial defects. Compared to other available materials, "Cordo Solution" is light in weight so that the resulting prosthesis approximates that of human flesh. The material is comparatively inexpensive, is easily repaired if damaged, and has a long shelf life after compounding. Molds of all types accept applications of "Cordo Solution" coating without difficulty. The material, in addition to providing a natural appearance and texture similar to human skin, has the following advantages:

1. translucence, nearly matching that of natural flesh
2. can be easily processed
3. colors well and can be surface tinted to match the skin tone of the patient
4. can be readily cleansed with mild soap and lukewarm water
5. retains its shape
6. is tough and resistant to tearing
7. has good durability
8. is not affected by most inorganic acids
9. is nontoxic to tissue
10. if color fades, its durable life can be extended by stripping away all external coloring and retinting to match the patient's flesh

The material is extremely flammable until it has been fully processed and the solvents have completely evaporated. After molding, the material becomes almost totally flame-resistant. While being slush molded, "Cordo Solution" has a tendency to fall away from the mold under conditions of 40 percent relative humidity in the processing area. This is surmounted by placing dehumidifiers in the work area. A prosthesis made totally of "Cordo Solution" will shrink away from its normal size if removed from the mold too soon. Cosmetic gloves remain in the mold 3 days at room temperature before their removal to reduce possible shrinkage. The solvents used to make Cordo solutions are organic, highly

volatile, and somewhat hazardous. For this reason they must be handled in a well-ventilated area and should not come in contact with unprotected skin. This hazard is completely removed when the solvents fully evaporate.

CONCLUSIONS

In 1949 the VAPC Restorations Laboratory started using polyvinyl chloride acetate solutions, commonly called "Cordo," for prosthetic restorations. Development of this material was started at that time and since then hundreds of cases have been satisfactorily treated. The method is presented as a useful adjunct in the prosthetic restoration of all similar cases. Complications should be removed if the prosthetist intending to use the material can be given an understanding of the basic processes of compounding "Cordo Solutions" and its many applications. The method continues to evolve and some new uses of Cordo are described by Byers, Nitschke, and Gardner in another article entitled "Total Contact Below-Knee Socket Liners of 'Cordo Solution': Fabrication Procedure" appearing elsewhere in this issue of the Bulletin.

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