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Connecting a Knife or Ice Pick to a Tire in a Tire Slashing

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ABSTRACT: Small particles of rubber cling to the metal object used to slash a tire. These particles are removed by a glass capillary tube and forced out of the capillary with water onto the top of a zinc chloride density gradient column. Automobile tire sidewall rubber varies in density from about 1.06 to 1.17, small truck tires vary from 1.13 to 1.17, and the value for large truck tires is about 1.2. Other rubbers and other objects all have densities different from sidewall rubber with the exception of a few synthetic fibers that can visually be distinguished from rubber.

KEY WORDS: criminalistics, rubber, chemical analysis

Several months ago there was a rash of tire slashings in the community in which the authors reside. One of the investigating officers stated that he was almost certain who was responsible but he had no way to tie the suspected ice pick to the tires involved. A search of the literature established that there were apparently no methods available to do this.

Remembering Locard's statement that "every contact leaves a trace," we decided to see if that could be shown to be true in this case. Several ice picks and a few double-edged hunting knives were stuck in the sidewalls of a tire. A microscopic examination at low power (5 to 20×) clearly revealed that several small pieces of rubber stuck to the slashing device. Figure 1 shows what these particles generally look like. The material was known to be rubber because the tire had just been stuck, but how could it be shown that an unknown particle was sidewall rubber? A call to the Goodyear tire laboratories established that sidewall rubbers generally have a density between 1.12 and 1.15 and that most tire companies' products would be in that range.

A density gradient column was then prepared to test types of rubbers and other material that might be found on a knife. The results are reported below.

Experimental Procedure

The equipment used in the procedure is listed in Table 1.

The gray ball from a battery tester (density $d = 1.148$) and the yellow ball from an antifreeze tester ($d = 1.077$) obtained from a local hardware store were used to set the limits of the appropriate density gradient section. The other balls were used only occa-

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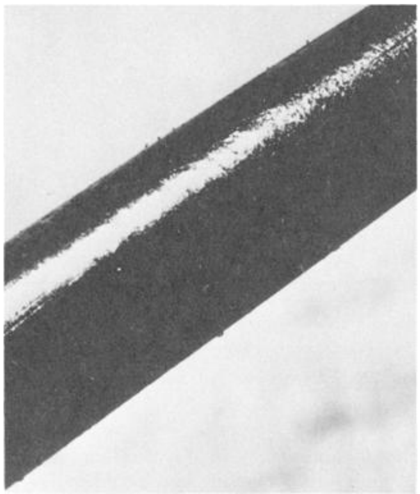

FIG. 1—*Sidewall rubber particles adhering to an ice pick.*

sionally; for example, the orange and green battery tester balls were used to identify truck tire sidewall rubber. A Westphal density balance was used to determine the density of the float balls (Table 2).

Concentrated zinc chloride (150 g/100 mL water) was used to prepare the density gradient column. The solutions used in the column are listed in Table 3. When preparing the solutions, avoid the material at the top of the concentrated zinc chloride because it may contain zinc carbonate.

Procedure 1

Place 4 mL of a concentrated zinc chloride solution into the bottom of a 25-mL buret. Add 20 mL of water and a small 3.2- by 6.4-mm (1/8- by 1/4-in.) plastic-coated magnetic stirring bar. Use another bar on the outside of the buret and with a top-to-bottom motion stir the solution for about 5 min [*1,2*].

Add the gray and yellow density calibration floats. Continue mixing until a 50- to 76-mm (2- to 3-in.) separation of the floats is achieved. If small, white particles of precipitate zinc hydoxide appear, add 0.5 mL of concentrated hydrochloric acid to adjust the pH and redissolve the particles.

TABLE 1—*Equipment used in the zinc chloride density gradient column procedure.*

Equipment	Supplier
Microscope	American Optical Co.
Microscope illuminator	American Optical Co.
Disposable microcapillary tube, 10 μL	Drummong Scientific Co.
Jeweler's forceps, Dumont style, #2	Wade's, Inc.
Buret, 25 mL	. . .
Captrol® or Microcap®	Bolab, Inc.
Buret reader, magnifying 10×	Pass Instrument Co.
Magnetic stirring bars (2), 3.2 by 6.4 mm (1/8 by 1/4 in.) and 6.4 by 12.7 mm (1/4 by 1/2 in.)	. . .

TABLE 2—*Density of the float balls.*

Float Balls	Density
Battery tester balls	
Gray	1.148
Orange	1.187
Green	1.237
Blue	1.244
Antifreeze tester balls	
Green	1.029
Orange	1.047
Blue	1.059
Yellow	1.077

TABLE 3—*Solutions required to prepare a zinc chloride gradient density column.* [a]

Density, g/cm^3	Weight of Zinc Chloride per 100 mL of Water, g
1.05	7.75
1.1	15.37
1.15	23.0
1.20	30.62
1.25	38.24
1.30	45.86

[a] Concentrated hydrochloric acid is also needed.

Attach the magnifying buret reader to the top of the buret.

Place the ice pick or knife blade under a wide-angle, lower-power microscope and locate the suspect particles. Remove them by either of two methods: (1) a jeweler's forceps or (2) a 10-μL glass capillary. If the jeweler's forceps is used, insert the tips below the top surface of the gradient column to overcome the surface tension and let the particle drop. Follow it down with the magnifier.

If the glass capillary is used (this holds several particles at one time) attach a Microcap holder that has been filled with water. Place the tip of the capillary just below the surface of the density column and force the particles out with a gentle stream of water, being careful not to allow air bubbles to adhere to the particle. This surface mixing does not affect the gradient further down the column. Follow the particles down with the magnifier. This takes from 3 to 30 min depending on the size and shape of the particle. If the particles are between the gray and yellow balls they are probably sidewall rubber.

Repeat by adding a small piece of sidewall rubber from the slashed tire to make a match. The piece added should be taken from as close to the original slash as possible.

Procedure 2

Prepare a density column by adding 4 mL of each of the zinc chloride solutions listed in Table 3 with the heaviest on the bottom. Use a Mohr pipet. Add distilled water up to 13 mm (0.5 in.) from the top of the buret.

Add the density gradient balls and let the column stand overnight to achieve equilibrium.

Proceed from here the same as in Procedure 1.

Results and Discussion

Procedure

Sodium chloride density gradients were investigated and found to be suitable but were not used for two reasons: (1) any leaks about the buret tip produced an unsightly salt deposit and (2) the most saturated solutions had a density just over 1.2.

Zinc chloride solutions, being more viscous, were found to be less likely to leak, and being hydroscopic, were easier to clean up. In addition, they offered a wider range of densities.

Several methods were examined for removing the small rubber particles: (1) a flat ground metal syringe needle, (2) a jeweler's forceps, and (3) a glass capillary.

The metal syringe could be used but it was impossible to see into it and small burrs on the ground tip had a tendency to hold the rubber particles in the tube. The thickness of the wall of a #18- or #20-gauge needle made it difficult to remove the particles from the suspect blade.

The jeweler's forceps work very well but positive control of the particle must be maintained. The particle must be firmly held. The particle cannot lay on one side of the forceps and only one particle at a time should be handled. When the forceps is inserted into the top of the column, unless a firm grip on the particle is maintained the particle cannot break the surface tension at the top of the column and will simply slide up the arm of the forceps. Also, the particle cannot be freed immediately because an air bubble is usually attached to it.

To overcome these difficulties a 10-μL clear glass capillary that has thin walls can be used. Several particles can be collected, and these are forced out of the tube by either one of two methods, both of which use water to force the particles out.

One way is to use a Captrol or a Microcap containing water. Insert the capillary tube inside of it and then, by squeezing the bulb, force the particles out. This small stream of water has a tendency to remove most of the air bubbles.

The second and preferred method is to fill the capillary with water, leaving 6 mm ($^1/_4$ in.) clear. Use this water-free end to collect the rubber particles and then attach the Captrol or Microcap as before. There are fewer and smaller air bubbles attached to the rubber particles when this technique is used (Fig. 2).

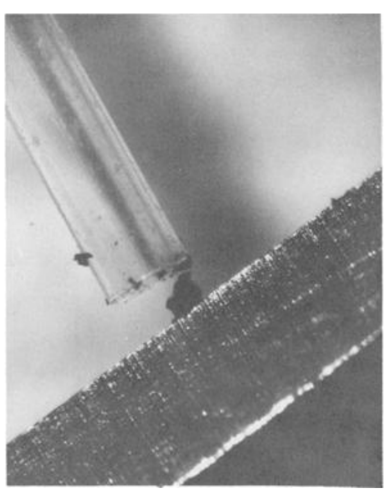

FIG. 2—*Microcapillary tube removing sidewall rubber particles from a knife blade.*

The density gradient, once formed, appeared to be stable for at least a week. The density marker balls would move 1 or 2 mm at most. Figure 3 shows a density column with several marker balls and several pieces of rubber. These pieces are large test pieces and should not be confused with the actual piece obtained from the blade.

Density of Objects Likely to be Encountered

Several materials that might be present on a knife blade were tested to determine their densities. Their densities were considerably different from sidewall rubber.

Table 4 shows that most materials likely to be on a knife blade have densities different from sidewall rubber. However, there are a few possible problems such as some asphalts, linoleums, and synthetic fibers.

Asphalt and linoleum will dissolve in hexane to give a dark black color but rubber will not. In addition, an experienced person can differentiate these from rubber by their appearance under the microscope and how they handle before the density measurement; a few plastics are in this same density range. If the plastics are in the form of synthetic fibers they are identifiable as fibers under a microscope lens. However, plastic such as shavings from a plastic object would be extremely difficult to differentiate if they were black. In that case a differential thermogram [5] may be obtained to show the difference.

Densities of Tire Sidewalls

Tires likely to be examined will be of various ages and from different manufacturers. What density range can be expected? Table 5 shows the results from 39 different tires, including five truck tires. The actual ages were unknown but during the sampling process the older tires were obvious. No real differences resulting from aging were found in the densities.

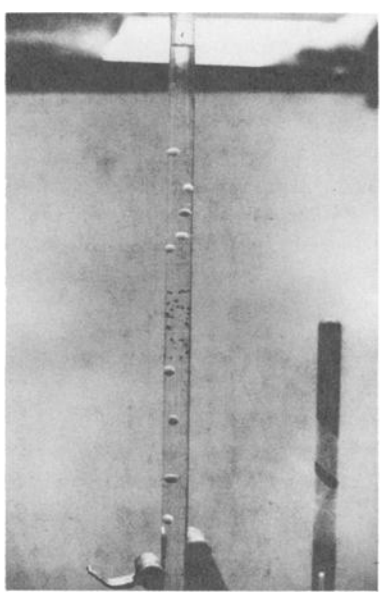

FIG. 3—*Sidewall rubber particles and density calibration floats in a gradient column.*

TABLE 4—*Densities of various materials* [3,4].

Material	Density g/cm^3
Charcoal	
Pine	0.28-0.44
Oak	0.57
Cardboard	0.69
Peat blocks	0.84
Leather, dry	0.87
Soft gum rubber	0.91-0.93
Butene-Diene® copolymer	0.915
Polyethylene	0.92
Styrene-butadiene copolymer	0.94
Tallow	0.94
Butadiene-acrylonitrile polymer	0.96-1.00
Coke	1.0-1.7
Tar	1.02
Blood plasma	1.03
Polyvinyl butyral, plasticized	1.05-1.50
Polystyrene	1.06
Ethylcellulose	1.07-1.18
Pitch	1.07
Asphalt	1.1-1.5
Soft common rubber	1.1
Cellulose acetate butyrate	1.1-1.23
Nylon	1.14-1.16
Nonrigid polyvinyl chloride acetate	1.15-1.45
Linoleum	1.18
Nonrigid polyvinyl chloride	1.18-1.65
Polymethylmethacrylate	1.18-1.2
Hard rubber	1.19
Dirt, most components	≥1.2
Bituminous coal	1.2-1.5
Dried blood	1.21
Neoprene (polychloroprene)	1.23
Cellulose acetate	1.25-1.5
Polyester	1.32-1.40
Rigid polyvinyl chloride acetate	1.35-1.45
Cellulose nitrate (nitrocellulose)	1.35-1.57
Polysulfide elastomer	1.35
Cellulose	1.4
Silicone rubber	1.4-2.0
Anthracite coal	1.4-1.8
Brick	1.4-2.2
Polyvinylidene chloride	1.65-1.72
Bone	1.7-2.0
Clay	1.8-2.6
Polytetrafluoroethylene	2.1-2.3

Table 6 shows the results of a statistical analysis of the tires listed in Table 5. Of the truck tires, three were from pickups and appeared to have a density of 1.15, while the value for big truck tires was 1.20. More samples from truck tires would have to be measured for statistical accuracy, but the trend is there.

Densities Within a Single Tire

Three types of measurements were made on the tires:

(1) every 25 mm or so around the sidewall of the tire (22 samples in one case, 44 in the other) (Fig. 4);

(2) a section from the tread line to the bead, every 1 cm (11 samples on the tire) (Fig. 5); and

(3) around a particular spot on a tire, first eight samples 1 cm away from the initial puncture and then eight samples equally spaced at a radius of 2 cm from the initial puncture (Fig. 6).

TABLE 5—*Densities of sidewall rubber from tires of different ages and manufacturers.*

Tire	Density	Tire	Density
		Cars	
General 78-15	1.09	Kelly L78-15	1.098
Dean Polaris G78-15	1.095	All American G70-14	1.11
Goodyear 78-15	1.11	Goodyear H78-15	1.095
Goodyear H78-14	1.06	J. C. Penney 78-14	1.096
Firestone 5.6-15	1.128	Firestone H78-15	1.11
Firestone GR78-15	1.098	Firestone B78-13	1.126
Firestone 9-14	1.07	Firestone 70-14	1.10
Firestone J78-15	1.116	Duralon C-78-13	1.174
Duralon DS	1.17	Goodrich 78-13	1.07
CO-OP 70-14	1.07	Concorde 70-14	1.14
Western Auto Supply L78-15	1.088	Multi Mile H78-15	1.10
Hercules 70-14	1.09	Hercules 6.70-15	1.144
Dunlop 7.75-14	1.118	Zenith LeMans 70-14	1.11
Bridgestone 165SR13	1.08	Sears All-State 7.75-14	1.095
Montgomery Ward H78-15	1.074	Mongomery Ward H78-15	1.075
Duralon DS	1.077	Kelly Springfield L78-15	1.094
Duralon C-78-13	1.115	Firestone 78-15	1.09
		Trucks	
Goodrich 6-17 eight-ply nylon	1.15	Hercules	1.15
Dayton 10-16.5	1.20	Goodyear 9-20	1.22
Dayton 7-17	1.16		

TABLE 6—*Statistical analysis of sidewall rubber densities.*

Type	Mean Density	Standard Deviation	Variance
Car	1.102	0.027	0.00069
Truck	1.176	0.032	0.00082

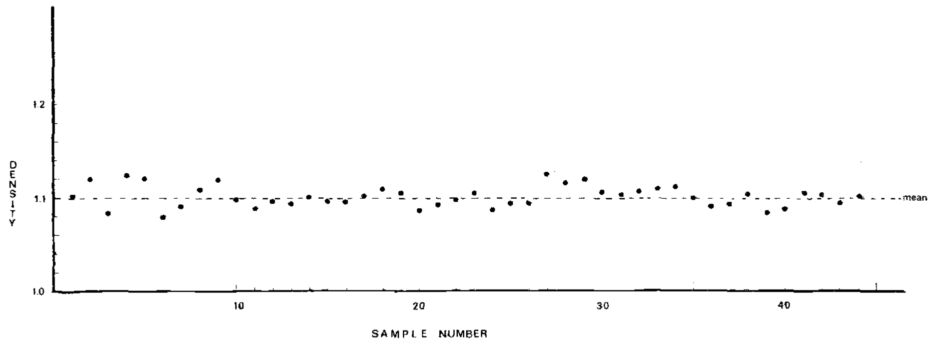

FIG. 4—*Density of 44 sidewall rubber particles taken from the sidewall circumference of the same tire.*

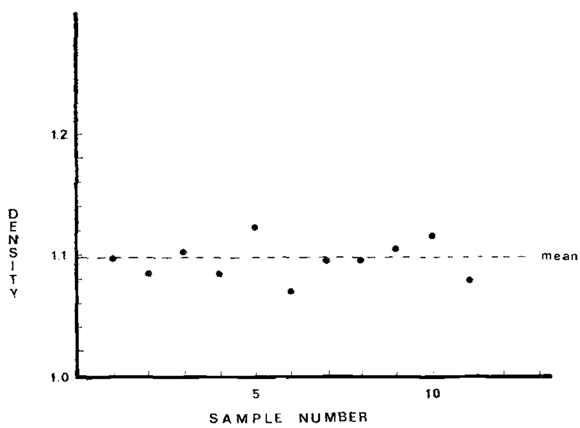

FIG. 5—*Density of 11 sidewall rubber particles taken from a linear segment between the bead and the tread.*

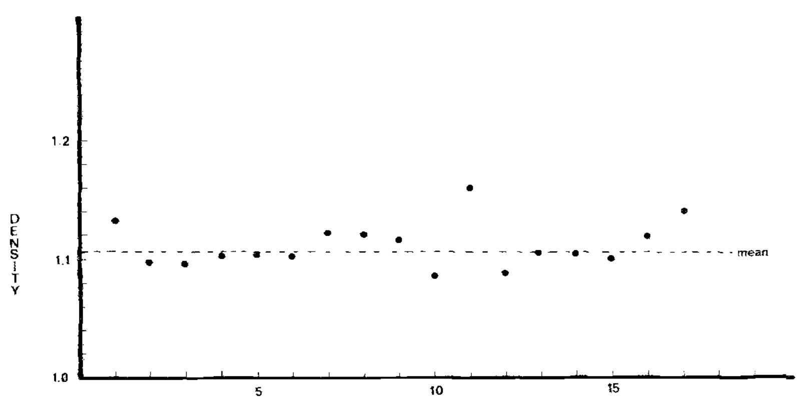

FIG. 6—*Density of 17 sidewall rubber particles located within a 2-cm-diameter circle.*

The results shown in Figs. 4 to 6 indicate that there is a slight deviation in the densities of sidewall rubber depending on where the sample is taken from, but this deviation is not so great as to preclude the identification of the particle as sidewall rubber.

Density differences from particles taken from the raised rubber lettering on the side of the tire were of no significant consequence.

White sidewall rubber was definitely heavier (1.23) than regular black rubber.

The standard deviations between samples taken from one tire and those taken from another tire indicate that while it is possible to show the particle is sidewall rubber it will be possible only in favorable cases to show that it came from a particular tire.

Pyrolysis gas chromatography may also be useful in identifying rubbers from sidewalls and may even be able to show differences between individual tires. Lack of equipment prevented the authors from performing such experiments.

Recommendations for Transporting the Evidence

These small particles of rubber are easily removed by rough handling. It is recommended that the handle of the knife or ice pick be taped to a hard board long enough to extend past the edge of the implement for transporting to the laboratory. Switch blades or other folding devices should not be closed because this jars off many particles.

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