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Flake Metal Powders for Revealing Latent Fingerprints

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ABSTRACT: Fine flake powders, having flake diameters ranging from 50 to 1 μm and stearic acid/powder ratios varying from 0 to 50 weight percent, were produced by laboratory-scale milling of aluminum, zinc, copper, and iron powders. The effectiveness of these flakes for detection of latent fingerprints was then assessed by comparing the print qualities obtained when using these flake powders with those achieved using commercial aluminum, commercial black, and commercial dark magnetic dusting powders. While the commercial aluminum powder was found to have an average flake diameter and stearic acid level close to the optimum values required to obtain bright fingerprints, several potential avenues of development were identified which could lead to the commercial availability of superior black powders.

KEYWORDS: criminalistics, fingerprints, flake metal powders, latent fingerprints

Fine flake metal powders are widely used for the detection of latent fingerprints. On a commercial scale, these flake products are generally manufactured by ball milling of near-spherical powders (up to about 100 μm in diameter) produced by atomization of liquid metal. The milling operation results in flattening and fracture of the atomized powder, which produces flake of the form illustrated in Fig. 1. Typically, the mean diameter of commercially available flake for fingerprint applications is around 10 μm, with an average flake thickness of approximately 0.5 μm. At present, aluminum flake powder is the most sensitive powder for revealing latent fingerprints and is recommended in the United Kingdom for use on most smooth nonporous surfaces [*1,2*]. Fingerprints developed with aluminum powder are normally transferred, using standard lifting tape, to transparent cobex sheets. The high reflectivity of the aluminum flake is then important when the prints are subsequently photographed for record purposes.

As evident from Figs. 2*a* and 2*b*, the flakes attach mainly to the ridges of the fingerprint, with few flakes located between the ridges. Production of fine flake with smooth reflective surfaces is promoted by the use of milling aids, such as stearic acid. Moreover, the resulting thin coating of stearic acid on the flake surfaces is an important factor in the adhesion of the flake to the latent fingerprint deposit. Indeed, removal of the stearic acid coating by solution in a suitable solvent seriously reduces the effectiveness of the flake for fingerprint development [*3*].

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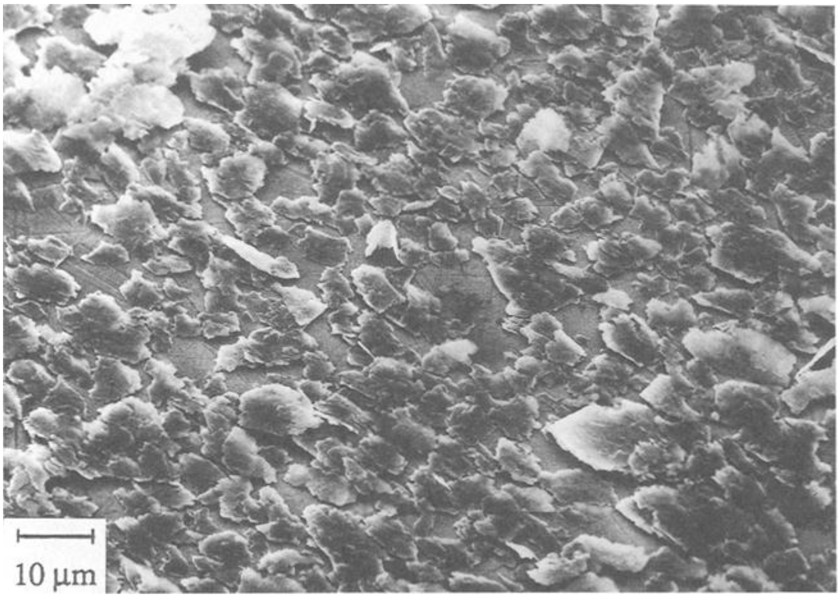

FIG. 1—*Scanning electron micrograph of commercial aluminum flake fingerprint powder.*

The aluminum and also the brass flake powders widely used for revealing fingerprints are manufactured primarily for tonnage applications, such as metallic paints, decorative printing, and packaging. For this reason, the large-scale milling equipment required for commercial flake production does not allow small quantities of flake to be supplied for trial purposes. Consequently, no systematic study has been undertaken to optimize the flake dimensions and stearic acid levels best suited to the task of revealing latent fingerprints. Similarly, little attention has been focused on the development of alternative metallic flake products which could prove superior to aluminum and brass powders for fingerprint detection. However, laboratory-scale milling procedures have been devised recently, which allow rapid manufacture of trial quantities of commercial-quality flake [*4*]. Using this technology to produce a range of different metallic flake powders with controlled particle dimensions and stearic acid levels, the present investigation was designed to identify improved flake products for forensic science applications.

Experimental Procedures

Laboratory Production of Flake Metal Powders

Four different pure metals were studied in the present investigation, namely, aluminum, zinc, copper, and iron. Aluminum was selected because of its widespread use for fingerprint detection. However, aluminum has a low density (2.70 Mg m^{-3}), so that aluminum flake tends to remain airborne during use. Zinc was therefore chosen with a view to producing flake with the color and reflective characteristics of aluminum, but with the faster settling rates expected for a material of comparatively high density (7.14 Mg m^{-3}). Copper and iron also have high densities, 8.92 and 7.86 Mg m^{-3}, respectively. Copper was included because of its distinctive reddish-brown color, which contrasts with the silver-grey appearance of aluminum, while iron was chosen in order to assess the potential advantages of a magnetic flake product.

For each material, flake was produced by milling of near-spherical powders, using high-energy ball milling procedures which have been described elsewhere [*4*]. The milling

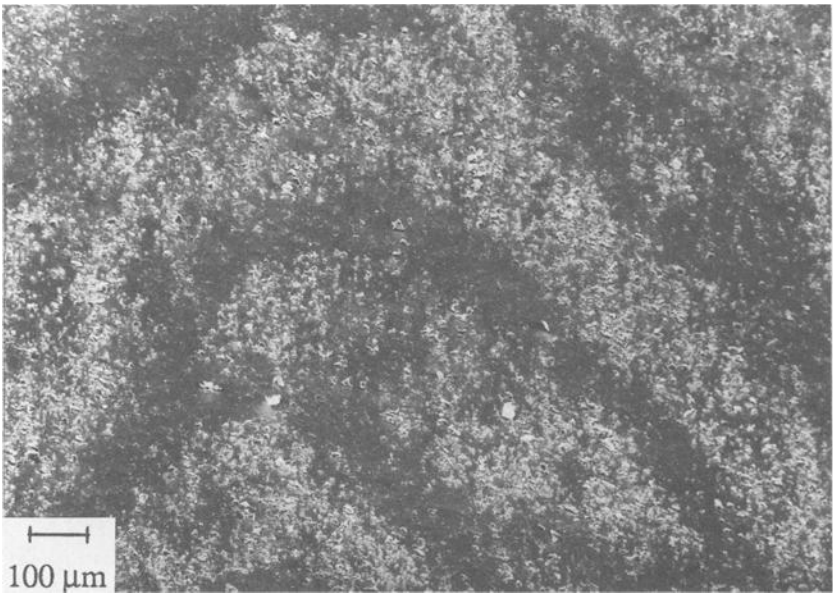

FIG. 2*a*—*Scanning electron micrograph of a latent fingerprint developed with the commercial aluminum powder.*

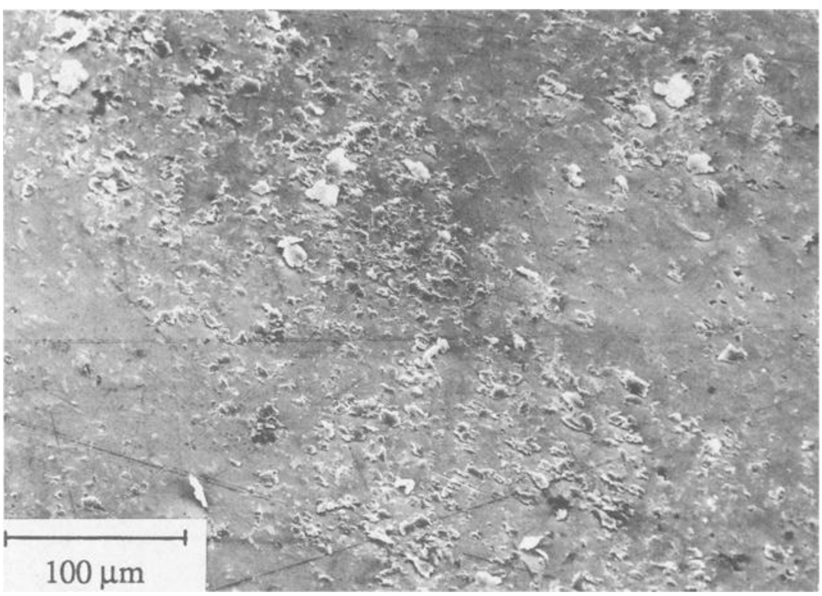

FIG. 2*b*—*A close-up view of a portion of one of the ridges in Fig.* 2a.

conditions were controlled to produce flake of around 0.5-μm thickness, but with mean flake diameters ranging from ~3 to ~50 μm (Table 1). In all cases, stearic acid was used as the milling aid. In order to clarify the effects of varying the stearic acid/powder ratio on the effectiveness of the flake for fingerprint detection, it was necessary to produce flake with stearic acid/powder ratios both lower and higher than the levels chosen for the milling operations. A reduction in stearic acid content was achieved by soxhlet washing with hot acetone, whereas higher ratios were obtained by milling the finished flake for a short period with predetermined quantities of additional stearic acid. Using these procedures, for each of the mean flake diameters listed for each of the four metals in Table 1, seven samples were prepared with the stearic acid/powder ratios specified in Table 2.

Brushes

Glass fiber brushes and squirrel hair brushes are widely used for applying powders to latent fingerprints. Since limited numbers of different powders are generally carried by scene-of-crime officers, a single brush can be reserved for each powder, thus avoiding powder cross-contamination. In contrast, in the present investigation, a very large number of different powders were manufactured and assessed. Squirrel hair brushes can be easily cleaned and are inexpensive. For this reason, the effectiveness of the aluminum, zinc, and copper powders was assessed using new or thoroughly cleaned squirrel hair brushes (size No. 8). However, with the magnetic iron powders, both squirrel hair brushes and "magnetic wand" applicators were employed.

Fingerprinting Procedures

The powders were assessed on latent fingerprints deposited on clean glass plates by a number of donors. While prints from different donors vary in the level of fingerprint residue, it was essential to ensure that all prints from any one donor were identical. A standard procedure was therefore adopted, with the donors rubbing their hands together in order to distribute the sweat evenly over fingers and palms. The nominated finger was then pressed onto a glass plate and removed. This procedure was repeated, pressing the same finger onto the next specified position on the plate using the same pressure and so on. In this way, an array of virtually identical fingerprints was obtained. After deposition, the fingerprints were left for one day before developing, because fingerprints developed at crime scenes are usually around one day old. Similar brushing procedures were then adopted for each powder, and the developed prints were transferred with standard lifting tape to cobex sheets for subsequent examination.

Powder Assessment Procedures

Since large numbers of flake powders were manufactured for the present study, a two-stage assessment procedure was adopted. Initially, each powder sample was assessed using the standardized fingerprints obtained from two donors. In the case of the iron powders, two sets of fingerprints from each donor were developed, one using squirrel hair brushes and the other using magnetic applicators.

While this procedure allowed the optimum flake size and stearic acid level to be determined for each of the four metal flake products investigated, any attempt to develop improved powders must include comparisons with widely used commercial products. Three materials were therefore chosen as standards, namely, commercial aluminum dusting powder, commercial black dusting powder, and commercial magnetic black dusting powder. The commercial dark powders were used to assess the laboratory-produced powders giving dark fingerprints.

The second stage of the assessment procedure then involved comparisons of the most effective of the laboratory-produced samples with the commercial standards. For this phase of the program, nine different donors deposited fingerprint sets using the procedures described earlier. A tenth donor then deposited "sebum-rich" fingerprints by rubbing the side of the nose with the index finger before depositing each print. All sets of prints were developed one day later using the best of the laboratory-produced powders and the commercial standards. To minimize subjectivity in this assessment exercise, an additional selection of prints was developed independently by two fingerprint specialists to validate the conclusions drawn.

Experimental Results

Aluminum Powders

All aluminum flake which had been soxhlet washed to achieve zero stearic acid levels resulted in poor fingerprint development. The best print development was obtained with a stearic acid/powder ratio of ~10 weight percent, but the changes in print quality were not pronounced over the entire range of stearic acid contents studied. In contrast, more distinctive trends were apparent with varying flake diameters. While aluminum powder with a mean flake diameter of ~50 μm gave poor print development, good prints were obtained with flake diameters of 10, 5, and 3 μm. The brightness of the print also varied with the flake diameter, the 50-μm sample producing very bright prints, while the 3-μm sample appeared dark grey.

Assessment of the laboratory-produced samples therefore suggested that the optimum flake diameter is around 5 to 10 μm and the optimum stearic acid/powder ratio is about 10 weight percent. The commercial aluminum powder chosen as the "standard" had a mean diameter of ~10 μm and a stearic acid level of ~3 to 5 weight percent. Since the powder costs increase with decreasing flake diameter and increasing stearic acid level, it appears that the commercial product is close to the optimum values identified for aluminum powder.

Zinc Powders

As with the aluminum powders, poor results were obtained with zinc flakes having a mean diameter of ~50 μm, with the optimum flake diameter being ~5 to ~10 μm. With both the 10 and 5-μm zinc flake, the optimum stearic acid content was around 3 to 5

TABLE 1—*Size ranges of flake powders produced for each metal.*

Metal	Approximate Mean Flake Diameter, μm			
Aluminum	50	10	5	3
Copper	50	10	5	1
Zinc	50	10	5	
Iron	50	25	10	3

TABLE 2—*Stearic acid/powder ratios studied for laboratory-produced flake, expressed as weight percent and volume percent.*

	Corresponding Volume %			
Weight %	Al	Cu	Zn	Fe
0	0	0	0	0
1	2.9	9.5	7.6	8.4
3	8.6	28.4	22.8	25.1
5	14.4	47.4	38.0	41.8
10	28.7	94.9	76.0	83.6
20	57.4	189.8	151.9	167.2
50	143.6	474.4	379.8	418.1

weight percent, with poorer results recorded with higher stearic acid levels. Again, as with the aluminum flake, the color of the prints developed with zinc powders varied from light grey for the 50-μm flake to dark grey for the 5-μm material. However, even the best of the laboratory-produced zinc samples were not quite as good as the commercial aluminum standard.

Copper Powders

Poor print development was again found with 50-μm diameter copper flake, but good prints could be obtained with flake having mean diameters of 10, 5, and 1 μm. With the finer flake sizes, prints of similar quality to that of the standard commercial aluminum powder were found with stearic acid levels of ~3 to 5 weight percent, but the print quality decreased with higher stearic acid contents. Again, a color trend with flake diameter was apparent, with a gradual transition from bright orangey-red to dark reddish-brown as the mean flake diameter decreased from 50 to 1 μm.

Iron Powders

When squirrel hair brushes were used to develop fingerprints with the laboratory-produced iron powders, virtually no print development was found for flake having mean diameters from 50 to 10 μm, independent of the stearic acid content. Some print development occurred with the 3-μm iron flake, with the optimum stearic acid content being about 3 to 5 weight percent. Even so, the best of the prints developed by applying the iron powders with squirrel hair brushes were substantially inferior to those obtained with the commercial aluminum standard.

In contrast, very good prints could be obtained using the magnetic applicator. While the 50-μm flake appeared comparable to the commercial black product and the commercial dark magnetic powder, even better print qualities were possible with the 25 and 10-μm iron powders. However, the 3-μm flake gave a very high background; it tended to "paint" over the latent fingerprints. The best prints for the 25 and 10-μm iron flake powders were found with samples containing 3 to 5 weight percent stearic acid. All these prints developed a dark grey color.

Discussion

Effect of Mean Flake Diameter

For all four pure metals considered in the present investigation, poor fingerprint development was found with powders having a mean flake diameter of ~50 μm, with flake of around 5 to 10 μm appearing optimum for powders applied with squirrel hair brushes. However, when a magnetic applicator was used with iron powders, excellent print qualities were observed with 10 and 25-μm flake, which suggests that larger flake diameters can be applied successfully with a magnetic wand.

Effect of Stearic Acid Contents

Although stearic acid levels are commonly defined as a weight percentage, a more useful comparison is achieved by calculating the volume percentages in order to compensate for the variation in the density of the metal under consideration. This conversion to volume percentages is particularly important for aluminum, which has a low density in comparison with zinc, copper, and iron (Table 2). For all materials studied in the present investigation, a stearic acid/powder ratio of around 20 to 40 volume percent appeared to be the optimum value.

Bright Flake Powders

The brightness of a fingerprint determines the way in which developed fingerprints are photographed to obtain permanent records. In all cases, the smaller flake diameters produced darker powders and, hence, darker fingerprints. This would be expected, since edge effects become more influential as the flake diameter decreases. In seeking to produce bright fingerprints, the surface of the flake powders should also be as flat and smooth as possible. For bright fingerprint development, the present study suggests that the commercial aluminum powder is close to the optimum flake diameter and stearic acid content. Unfortunately, in attempting to reduce "airborne" dust by developing high-density zinc flake as a replacement for aluminum, the current range of zinc flake products resulted in print development inferior to the quality attainable with the commercial aluminum standard. However, if a reddish print appearance is advantageous, copper powder with a flake diameter of ~10 μm and a stearic acid content of ~20 to 40 volume percent gives print qualities comparable or only slightly inferior to the commercial aluminum.

Dark Fingerprint Powders

The present investigation suggests that, while excellent commercial aluminum powders are available for obtaining bright fingerprints, several development avenues exist which could lead to the commercial availability of superior "dark powders" for print detection on light backgrounds. Thus, the 3-μm aluminum powder produced better prints than the commercial black product, although the laboratory-produced sample gave higher backgrounds. Similarly, the 1-μm copper powder developed prints to a level comparable with that of the commercial black product. More importantly, both the 10 and 25-μm iron flake powders gave excellent print development, provided only that these laboratory-produced samples were applied using a magnetic wand. In fact, the prints developed with these iron flake powders were superior to those produced with commercially available magnetic powders and directly comparable in quality to prints developed with the commercial aluminum powder. Furthermore, application of these iron powders with a magnetic wand offers the potential advantage of minimizing airborne dust.

Conclusions

1. Commercial aluminum powders have flake diameters and stearic acid levels close to the optimum values required for development of bright fingerprints.

2. In seeking to reduce airborne dust levels by replacing aluminum flake with high-density zinc flake, the best print qualities achieved with the zinc powders were inferior to those obtained with commercial aluminum powder.

3. With the laboratory-produced copper powders, flake of ~10-μm diameter produced prints of a reddish color and a quality close to that obtained using commercial aluminum powder, while 1-μm copper flake was comparable to commercial black powder for fingerprint detection.

4. Iron powders applied with a magnetic wand offer major development potential for fingerprint detection on light backgrounds, with the laboratory-produced 10 and 25-μm iron flake products being significantly superior to the black powders and magnetic black powders available commercially.

Acknowledgment

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