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Factors Affecting the Diffusion of Printing Ink (Mud)

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Abstract: At present, with the growing demand for document production time identification at home and abroad, a large number of acts of forgery of document production time have emerged in the judicial identification activities, which has brought great challenges to the document judicial identification work and judicial trial. In order to meet this challenge, ensure the accuracy of document production time inspection results, and solve the problem of the time for the formation of seal, fingerprint and impression on documents. The author uses direct contact between ink (mud) and paper, the diffusion area, shape and overall speed of ink (mud) molecules were observed under the fluorescence with wavelength of 645-695nm. Combined with the factors affecting the diffusion change of ink (mud) molecules, the relative formation time of stamped seal, fingerprint and imprint on paper was judged by the diffusion area and overall speed of oil marks, and the differences were distinguished by the diffusion shape and physical and chemical analysis. (slurries). The analysis results not only help us understand the various factors that affect the diffusion form and speed of ink (mud), but also solve the relative formation time of stamped and imprinted fingerprints and imprints on paper, distinguish the diffusion form and type of different seal imprints, and distinguish the composition of ink.

Keywords: Diffusion Area, Overall Speed, Formation Time

1. Introduction

Molecular diffusion, also known as molecular mass transfer or diffusion, is a phenomenon of material transfer formed by the irregular thermal movement of molecules in Weifang, Shandong Province [1]. The ink (mud) on paper changes over time and forms molecular diffusion due to the irregular thermal movement of molecules. The diffusion volume and overall speed are directly related to temperature, humidity, and material properties. Under the same material properties, the higher the temperature and humidity, the more intense the thermal movement of molecules. On the contrary, the opposite is true. At present, there are many methods for detecting printing oil, such as gravimetric method, pyknometer method, turbidimetric (solvent transformation) method, turbidimetric (ultrasonic) method, gas chromatography method, resistance method, pyrolysis method, ultraviolet spectrophotometry, fluorescence method, non dispersive infrared method, three wave number infrared spectrophotometry, etc. The author mainly uses fluorescence method and gravimetric method to analyze the composition and physical characteristics of printing oil.

2. Materials and Methods

2.1. Observing the Diffusion Phenomenon of Imprint Molecules Under the Same Conditions

1) 70gA4 paper; 2) Chenguang brand AYZ975B2 universal quick drying printing oil; 3) Temperature 25°C; 4) Keep away from light (cabinet); 5) Observation under fluorescence with wavelengths of 645-695nm; 6) The collection time is the same (once a week).

2.2. The Effect of Different Paper Thickness on the Diffusion of Ink Molecules

1) 80g, 100g, 120g A4 paper (made of the same material); 2) Deli brand photosensitive printing ink; 3) Temperature 25°C; 4) Keep away from light (cabinet); 5) Observation under fluorescence with wavelengths of 645-695nm; 6) The collection time is the same (once a week).

2.3. Using Physical and Chemical Methods to Distinguish the Composition of Different Printing Oil (Mud) Substances

2.3.1. Chemical Method Main Reagents

Deli brand number 9879 photosensitive printing oil 2g, 95% or 99% alcohol, water, sodium hydroxide 0.0101mol/L. Instrument: water bath heating device, vacuum filter device, glass beaker, glass rod, electronic scale with precision of 0.01g, aperture of 0.22μ M hydrophilic filter paper.

Main reagents: Chenguang brand AYZ975B2 universal quick drying printing oil 2g, analytical pure 60-90 petroleum ether, sodium hydroxide 0.0101 mol/L, diluted hydrochloric acid 20%. Instrument: water bath and fire bath heating device, vacuum filter device, glass beaker, glass rod, electronic scale with precision of 0.01g, aperture of 0.22 μ M hydrophilic filter paper [2].

2.3.2. Physical Methods

1) Drop Deli brand number 9879 photosensitive printing oil and Chenguang brand AYZ975B2 universal quick dry printing oil onto 70gA4 paper respectively, observe their color and diffusion. 2) Dissolve plant oil alcohol soluble printing oil, such as Deli brand number 9879 photosensitive printing oil, in anhydrous ethanol. Dissolve mineral oil based printing oil, such as Chenguang brand AYZ975B2 universal quick dry printing oil, in petroleum ether to observe their solubility, 3) Observe the fluorescence characteristics of both under fluorescence at wavelengths of 645-695nm.

2.4. The Effect of Different Components of Impression Oil on Molecular Diffusion Phenomenon

1) 80gA4 paper; 2) Jinmai and Chenguang brand photosensitive printing oils; 3) Temperature 25°C; 4) Keep away from light (cabinet); 5) Observation under fluorescence with wavelengths of 645-695nm; 6) The collection time is the same (once a week).

2.5. The Effect of Different Capping Pressure on the Diffusion Phenomenon of Imprint Oil Molecules

1) 80gA4 paper; 2) Jinmai brand photosensitive printing oil; 3) Temperature 25°C; 4) Keep away from light (cabinet); 5) Observation under fluorescence with wavelengths of 645-695nm; 6) The collection time is the same (once a week).

2.6. The Influence of Different Seal Materials on the Diffusion Phenomenon of Imprint Molecules

1) 70gA4 paper; 2) Chenguang brand photosensitive printing oil; 3) Rubber machine engraved seals, permeable photosensitive seals; 4) Temperature 25°C; 5) Keep away from light (cabinet); 6) Observation under fluorescence with wavelengths of 645-695nm; 7) The collection time is the same (once a week).

2.7. The Effect of Different Concentrations on the Diffusion Phenomenon of Printing Oil Molecules

1) 70gA4 paper; 2) Different batches of Chenguang brand AYZ975B2 universal quick drying printing oil, Jinmai and Zeyuan photosensitive printing oil; 3) Temperature 25°C; 4) Keep away from light (cabinet); 5) Observation under fluorescence with wavelengths of 645-695nm; 6) The collection time is the same (once a week).

2.8. The Effect of Different Temperatures on the Diffusion Phenomenon of Printing Oil Molecules

1) 70gA4 paper; 2) Chenguang brand photosensitive printing oil; 3) Temperature 25°C, 38 degrees; 4) Keep away from light (cabinet); 5) Observation under fluorescence with wavelengths of 645-695nm; 6) The collection time is the same (once a week).

3. Results and Discussion

3.1. Observe the Diffusion Phenomenon of Imprint Molecules Under the Same Conditions (Figure 1)

Under fluorescence with wavelengths of 645-695nm, the phenomenon of diffusion of imprinted oil molecules can be observed [3]. By comparing the diffusion signs at each time period, it was found that under the same conditions, the diffusion area and overall speed of imprinted oil molecules gradually increase with time. Finally, when the imprinted oil molecules reach equilibrium, diffusion stops, and the diffusion speed and area no longer increase [4].

Time/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Length/cm	0.19	0.21	0.23	0.24	0.25	0.25	0.26	0.26	0.26	0.27	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30	0.30

Figure 1. *Spread phenomenon of oil mark of Chenguang AYZ975B2 Pratt & Whitney quick-drying printing ink.*

3.2. The Effect of Different Paper Thicknesses on the Diffusion Phenomenon of Ink Molecules (Figure 2)

By comparing the diffusion signs of different paper thicknesses and the same time period, it was found that different paper thicknesses result in different diffusion areas and overall velocities. Under the same material conditions (ink and paper material), 80g paper diffuses faster and has a

larger area. 100g paper has a slightly faster diffusion speed and a slightly larger diffusion area than 120g paper. The same component of printing ink (Deli brand number 9879 photosensitive printing ink) has different paper thicknesses and fluorescent colors of oil stains (Figure 3).

Time/Week	1	2	3	4	5	6	7
Length/cm	0.05	0.10	0.13	0.14	0.16	0.18	0.18

80g/paper

Time/Week	1	2	3	4	5	6	7
Length/cm	0.04	0.07	0.10	0.10	0.10	0.12	0.13

100g/paper

Time/Week	1	2	3	4	5	6	7
Length/cm	0.03	0.07	0.09	0.09	0.09	0.11	0.12

120g/paper

Figure 2. *Deli brand No. 9879 photosensitive printing oil on paper of different.*

80g 100g 120g

Figure 3. *Color and color of photosensitive printing oil mark with Deli brand number 9879 under different paper thicknesses.*

3.3. The Effect of Different Components of Impression Oil on Molecular Diffusion Phenomenon

There are basically two types of ink pigments, dye type and pigment type [5]. The dye type has a bright color, a glossy feeling, a small molecular weight, good solubility, makes objects fully colored, without layering, and has a high density of binding between the pigment and the solvent. The pigment type has a dark color, strong coverage, poor gloss, high molecular weight, poor solubility, partial coloring of the object, obvious layering of the pigment and solvent, poor binding density between the pigment and solvent, and obvious solvent diffusion (Figure 4) [6].

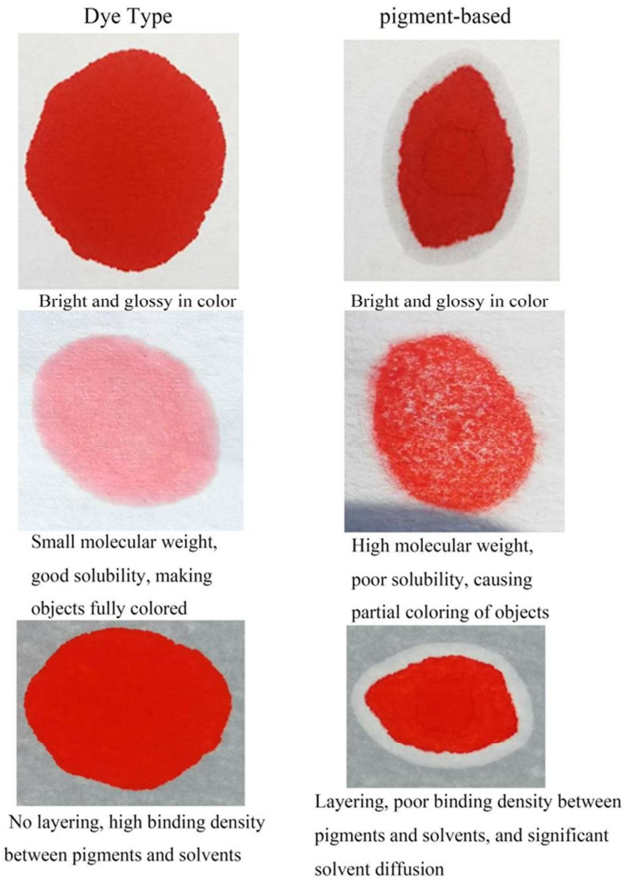

Figure 4. *The difference between dye and pigment inks.*

Figure 5. *Comparison of fluorescent color of oil marks between plants and minerals.*

Time/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Length/cm	0.19	0.21	0.23	0.24	0.25	0.25	0.26	0.26	0.26	0.27	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30	0.30

Diffusion data of pigment based mineral oil printing oil

Time/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Length/cm	0.10	0.12	0.16	0.16	0.18	0.19	0.21	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.24	0.24	0.27	0.27	0.27

Dye based vegetable oil printing oil diffusion data

Figure 6. *Comparison of diffusion data between pigment based mineral oils and dye based vegetable oils.*

There are two types of printing oil solvents, plant bas ed and mineral based oils [7]. When observed under flu orescence wavelengths of 645-695nm, the excitation fluo rescence color of the two is different. The fluorescence color of plant based oil stains is brighter, while the fluo rescence color of mineral based oil stains is darker (Fig ure 5) [8].

By analyzing the data in Figure 6, it was found that the diffusion rate of pigment based mineral oil printing oil was faster than that of dye based plant oil printing oil in the first

week, due to the poor binding density between pigment based pigments and solvents and significant solvent diffusion. From the second week, the overall diffusion rate of dye based plant oil printing oil was faster than that of pigment based mineral oil printing oil, and the diffusion of pigment based mineral oil printing oil stopped in the 15th week, Dye based plant-based oil prints stopped diffusing in the 17th week, with a longer diffusion time and a smaller diffusion area than pigment based mineral oil prints.

3.4. The Effect of Different Cap Pressures on the Diffusion Phenomenon of Imprint Molecules (Figure 7)

Time/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Length/cm	0.10	0.12	0.16	0.16	0.18	0.19	0.21	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.24	0.24	0.27	0.27	0.27

High pressure, thick ink coverage, and diffusion data

Time/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Length/cm	0.05	0.05	0.05	0.06	0.07	0.07	0.08	0.08	0.10	0.10	0.10	0.10	0.14	0.14	0.15	0.15	0.15	0.15	0.15

Low pressure, thin oil coverage, and diffusion data

Figure 7. *Oil mark diffusion data of different cap pressures.*

As shown in Figure 7, under the same conditions, comparing the diffusion signs of oil molecules under different sealing pressures, it was found that the higher the sealing pressure, the thicker the oil cover on the paper surface, the faster the diffusion speed, and the larger the diffusion area. When the imprint molecules reach equilibrium, the diffusion stops for a longer time.

3.5. The Effect of Different Seal Materials on the Diffusion Phenomenon of Imprint Molecules (Figure 8)

Time/Week	1	2	3	4	5	6	7	8
Length/cm	0.05	0.05	0.07	0.10	0.11	0.13	0.15	0.15

Permeable Seal Diffusion Data

Time/Week	1	2	3	4	5	6	7	8
Length/cm	0.04	0.07	0.07	0.07	0.08	0.10	0.11	0.12

Machine engraved rubber seal diffusion data

Figure 8. *Comparison of Permeability and Machine Engraved Seal Diffusion Data.*

As shown in Figure 8, the composition of the ink is the same, and the diffusion speed of the permeable seal is slightly faster than that of the machine engraved seal. Excluding the factor of oil coverage, the main reason is that the machine engraved seal is affected by the material of the printing platform and the sealing method [9]. Under fluorescence with wavelengths of 645-695nm, the diffusion patterns of oil marks on permeable seals and machine engraved seals were observed. The diffusion patterns of oil marks on permeable seals were evenly distributed, while those on machine engraved seals were opposite (Figure 9). The main reason is that the distribution uniformity of the two printing oils is different [10].

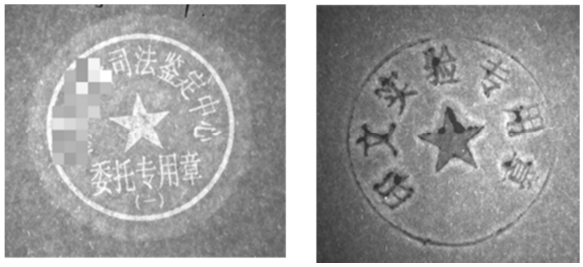

Figure 9. *Diffusion form of oil mark of permeable seal (left) and machine-engraved seal (right).*

3.6. The Effect of Different Concentrations on the Diffusion Phenomenon of Imprint Molecules (Figure 10)

Time/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Length/cm	0.19	0.21	0.23	0.24	0.25	0.25	0.26	0.26	0.26	0.27	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30	0.30

Purchase the first batch (Chenguang brand AYZ975B2 universal quick drying printing oil)

Time/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Length/cm	0.13	0.15	0.19	0.21	0.23	0.23	0.24	0.24	0.24	0.26	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27

Purchase the second batch (Chenguang brand AYZ975B2 universal quick drying printing oil)

Time/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Length/cm	0.10	0.12	0.16	0.16	0.18	0.19	0.21	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.24	0.24	0.27	0.27	0.27

Jinmai brand photosensitive printing oil

Time/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Length/cm	0.12	0.16	0.17	0.20	0.22	0.23	0.25	0.25	0.25	0.27	0.28	0.31	0.31	0.33	0.33	0.33	0.33	0.33	0.33

Zeyuan brand photosensitive printing oil

Figure 10. *Diffusion data of oil marks with different concentrations.*

As shown in Figure 10, Chenguang brand AYZ975B2 universal fast drying printing oil is purchased in two batches, with different ratios of pigments and solvents. The first and second batches have ratios of (0.19:1.81) and (0.2:1.8), respectively. Both are mineral oil pigment based printing oils, while Jinmai and Zeyuan brand photosensitive printing oils have ratios of (0.2:1.8) and (0.14:1.86), respectively, both of which are vegetable oil dye based printing oils [11]. Observing the above data shows that the smaller the concentration of the excellent material, the faster the diffusion speed, and the larger the diffusion area. Mineral oil pigment based printing oils and vegetable oil dye based printing oils have similar diffusion areas at the same pigment concentration, but the former has a faster diffusion rate and basically stops diffusion at the 11th week, while the latter has a relatively slow diffusion rate and stops diffusion at the 16th week. Under the same color concentration, the diffusion speed and stop diffusion time vary depending on the composition of the printing oil. Some printing oil solvents contain cross-linking agent components (such as resins, oily thickeners, etc.). When the cross-linking agent components in the solvent are the same, the higher the cross-linking agent content, the slower the diffusion speed, and the smaller the diffusion area. When the components of the crosslinking agent in the solvent are different, the stronger the combination of the crosslinking agent with the solvent and pigment, the slower the diffusion speed, and the smaller the diffusion area.

3.7. The Effect of Different Temperatures on the Diffusion Phenomenon of Imprint Molecules (Figure 11)

As shown in Figure 11, the diffusion data of Chenguang brand AYZ975B2 universal fast drying printing oil were observed at different temperatures [12]. The higher the temperature, the faster the diffusion rate at week 1, and after week 4, the diffusion rate was significantly slower than at low temperatures.

Time/Week	1	2	3	4	5	6	7
Length/cm	0.07	0.10	0.10	0.11	0.16	0.24	0.29

Temperature 25 ℃

Time/Week	1	2	3	4	5	6	7
Length/cm	0.19	0.21	0.23	0.24	0.25	0.25	0.26

Temperature 38 ℃

Figure 11. *Oil mark diffusion data at different temperatures.*

4. Conclusion

Under fluorescence with wavelengths of 645-695nm, the diffusion phenomenon of imprint molecules can be clearly observed. For the same composition of imprint, when the paper is thinner, the diffusion speed is faster, the area is larger, and the fluorescence color of the oil mark is brighter. When the sealing pad material is the same paper, the smaller the concentration of the same component ink (mud) pigment, the faster the diffusion speed, and the larger the area. Under the same color concentration, the diffusion speed and stop diffusion time vary depending on the composition of the printing oil. Dye based plant-based oil prints stopped diffusing in the 17th week, with a longer diffusion time and a smaller diffusion area than pigment based mineral oil prints. When the components of the crosslinking agent in the solvent are the same, the higher the content of the crosslinking agent, the slower the diffusion speed and the smaller the diffusion area. When the components of the crosslinking agent in the solvent are different, the stronger the combination of the molecular structure of the crosslinking agent with the solvent and pigment, the slower the diffusion speed and the smaller the diffusion area. The two stimulate different fluorescence colors, with plant oil stains having brighter fluorescence colors and mineral oil stains having darker fluorescence colors. Under the same conditions, the higher the stamping pressure, the thicker the oil cover on the surface of the paper, the faster the diffusion speed, the larger the diffusion area, and the longer the stop diffusion time when the oil molecules reach equilibrium. The material or sealing conditions of the seal are different, and the distribution of the oil mark diffusion form is different. The oil mark diffusion form of the permeable seal is evenly distributed, and the diffusion speed is slightly faster. The higher the storage temperature, the faster the diffusion rate in the first week. After the fourth week, the diffusion rate was significantly slower than that at low temperatures (the above data analysis is limited to the types and batches of ink purchased by the author. If there are errors, the analysis reasons are the distribution rate of ink at the cutoff point, temperature control accuracy, purchase batch, and manufacturer formula update).

In summary, the factors that affect the diffusion form and speed of printing oil (mud) include: 1) the composition of printing oil (mud); 2) Sealing conditions (such as padding and seal material, process, sealing method, etc.); 3) Sealing pressure (such as thick or thin coverage of printing oil (mud)); 4) Storage environment (temperature, humidity, etc.); 5) Printing oil production process.

We can use the diffusion form and speed of ink to solve some problems in practical work, such as determining the relative formation time of stamping or stamping, the type of seal, the composition of ink, etc. However, the premise should be to exclude various factors that affect the diffusion form and speed of ink (mud), and combine other inspection methods, such as the physical and chemical characteristics of paper fibers [13], ink (mud) oxidation when exposed to air, such as color changes, material wear, and other phenomena [14], Based on other elements on the document, such as signature and content, handwritten handwriting, printed handwriting, and ink timing, a comprehensive analysis is conducted [15].

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