Study on the Influencing Factors in the Process of Surface Strippable Decontaminant

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Abstract: One effective measure of radioactive material purification is the use of strippable decontaminants, which effectively coat the pollutant, capture suspended particles in the air, and deposit them onto the surfaces of objects. However, there are some shortcomings in terms of film formation and peelability, such as a brittle coating and poor peelability. Therefore, in order to meet future military and emergency needs, this research investigated the influencing factors in the process of surface strippable decontamination. Experiments included tests for wettability, potential, particle size, strippable performance, tensile performance, ultraviolet transmittance reflectance, and film formation as well as image analysis of photomicrographs from an optical microscope system. These experiments indicate that the strippable decontaminant is a viable means of contamination removal.

Keywords: stripping; enclosed; decontaminant

1. Introduction

A large degree of radioactive surface contamination occurs during the operation and retirement of nuclear facilities, the transport of nuclear materials, and in the case of nuclear accidents. When large amounts of surface contaminants are moved, transported, or even decontaminated, they can cause the surface discharge of pollutants into the atmosphere, which leads to the generation of radioactive aerosols and environmental problems.

Traditional radioactive surface decontamination methods, which are time-consuming and expensive, can cause airborne hazards and do not always reduce the concentration of the contaminant to acceptable levels. The methods for removing contaminants from the surface are generally divided into physical methods and chemical methods. Physical methods include mechanical decontamination, sandblasting, ultrasonic decontamination, washing, and decontamination [1–3]. Chemical decontamination methods include reagent washing, electrochemical gel decontamination, and self-brittle film peeling [4–7]. The common problem with existing decontamination methods is that secondary pollution occurs easily. For example, the application of high-pressure jet cleaning to the surface of a nuclear accident site and the use of ammonium salt for ion cleaning to promote the exchange of radioactive cesium ions have been limited because these two approaches have produced a large amount of radioactive contaminated water [8–11]. Therefore, the surface purification of radioactive materials is an urgent...
and important task. Contaminants may be carried for several city blocks as a result of different environmental conditions [12,13], and eventually settling on surfaces such as buildings, streets, grass, and soil. For example, if the wind speed is 5 m per second in London, within 2 min, the radioactive plume has traveled about 10 blocks, past government buildings and to the Prime Minister’s house. In another minute, it will cross the Thames River. It will take just half an hour for the cloud to reach London’s suburbs six miles east of the hypothetical nuclear accident [14].

The use of the strippable decontaminant will eliminate the generation of airborne dust during the cleaning process and is a more efficient method of abatement, which reduces the dust levels to acceptable levels [15]. As one effective measure of radioactive material purification, a strippable decontaminant [16–18], which effectively coats pollutants, captures suspended particles in the air, and deposits them onto the surfaces of objects. This was developed for the purpose of capturing, enriching, and stripping surface pollutants [19,20], and, thereby, decreasing the hazardous dust concentrations to acceptable levels.

Zhou et al. [21] prepared self-brittle decontamination coatings by emulsion polymerization. Gertzmann R. et al. [22] used acrylate and methacrylate to prepare water-based decontamination coatings by emulsion polymerization, which can be widely used on glass, metal, and plastic surfaces. William M.M. et al. [23], using the emulsion polymerization method, prepared water-based peel emulsion decontamination coatings, which exhibited excellent protective effects and were easy to peel off. Shan et al. [24] prepared a water-based peel coating with acrylic polymer emulsion. The coatings had good water resistance, protective effects, and adhesion. Yin et al. [25] reported an efficient approach for fabricating a strippable coating that involved doping SO$_4^{2-}$/TiO$_2$ into polyphenylamine. When compared with traditional decontamination coatings, this coating had good electrical conductivity, and the decontamination efficiency was more than 97%. Li et al. [26,27] reported that a type of gas-phase antirust coating was prepared using vinyl polymer resin as the main film-forming material by adding a compound oil–soluble gas phase corrosion inhibitor, epoxy resin, toughening agent, stabilizer, antioxidant, lubricating oil, and mixed solvent. In the study of Sun et al. [28], ethyl alcohol was used as the solvent, and DAP (O-benzenedicarboxylic acid diallyl ester) was used as the reactive monomer to prepare P-DAP. By using the P-DAP prepolymer as the main film-forming material, TPGDA (Diallyl Phthalate Prepolymer) as the active diluent, and bis (2,4,6-trimethylbenzoyl) phenylphosphorous oxide (BAPO) as the light initiator. A new type of UV (Ultraviolet)-curable strippable coating was prepared. Wan [29], using the emulsion polymerization method, prepared water-based peel emulsion decontamination coatings, which exhibited an excellent protective effect and were easy to peel off. Water-based peeling coatings have the advantages of simple construction, rapid drying, and good transparency.

However, there are some shortcomings in film formation and peelability, such as brittle coating and poor peelability. As a result, their application is greatly restricted. Therefore, in order to keep equipment in good condition at all times and to meet emergency needs, future strippable protective coatings will need to possess the following properties for comprehensive performance.

1. Short curing time, good physical properties, no corrosion of the equipment surface, and friendly to the environment.
2. The film body formed by the coating has excellent sealing and mechanical properties such as better elongation at break and tensile strength.
3. The painting process is simple, and the adhesion is moderate. It can adapt to different object interfaces and can be quickly and completely peeled off.

There have been no in-depth studies on how decontaminants interact with pollutants and the physical or chemical processes that they undergo during the action of decontamination. For example, the research on the mechanism of decontamination is not yet well established. From Figure 1, it can be seen that, in previous studies on the action of the decontamination agent, the decontamination process is divided into the following steps: (1) the decontaminant is applied to surfaces, (2) the decontaminant
is cured on surfaces, (3) after a period of time, the decontaminant solidifies on the surface and mixes with the contaminants, and (4) the decontaminant is removed after surfaces are cured to remove contaminants. In addition, the decontamination process is the key factor affecting decontamination efficiency. If the division of the decontamination process is not accurate, the factors affecting this process cannot be determined accurately.

In this study, starting with the latex particles of the synthetic decontaminant, for different decontamination objects, the aggregation state of the latex particles on the surface of the pollutant during the decontamination process is analyzed to further illustrate the decontamination process of the decontaminant.

The existing research has provided a relatively simple characterization of the decontamination performance of decontaminants, and most of them indirectly speculate about the influence on the decontamination effect by studying the performance of the decontamination materials themselves. However, there are few studies on the direct action of the decontaminant and pollutants.

Therefore, it is necessary to find a suitable method to characterize the microscopic mechanism of decontaminants. Through a study on the decontaminant particles, which are the main components of the decontaminant, the roles of decontaminant particles and pollutants in the process of decontamination are analyzed. The steps that the decontaminant takes in the decontamination process are verified, and experimental support for the study of the decontamination mechanism is provided.

In addition, the accuracy of the decontamination process will affect its analysis. At present, the characterization of the decontamination process mainly focuses on the effect of the decontaminant forming the film, the peeling of the decontaminant after curing, and the surface cleanliness after peeling. To date, there is little research on the process of decontaminants and pollutants in the curing process. Therefore, through the accurate division of the process steps of the decontaminant, the influencing factors involved in the decontamination process are analyzed. This part of the evaluation mainly analyzes and studies the mechanism on the effect of the decontaminant on different decontamination objects in an aim to establish a more accurate method of microscopic process characterization of the decontamination effect.

The mechanism of action of a decontaminant in the process of pressing and stripping and guidance on the design, preparation, and synthesis of a stripping decontaminant are the problems that need to be studied and solved in this paper.

In this paper, the influencing factors during the process of decontamination and the reaction between the decontaminant and the surface pollutant were studied to guide and optimize the synthesis and preparation of decontaminants. Previously synthetically prepared strippable decontaminants
were used as research objects to characterize the decontamination process on the surface of an object. The factors that affect the stability of the decontaminant, the coating cure, and the combination between the contaminants and the polymer matrix were studied by a surface tension tester, optical microscope system, and universal testing machine. Through the accurate division of the decontamination process and the analysis of the physical and chemical influencing factors involved in the decontamination process, a more intuitive and accurate decontamination process description can be established, and the influencing factors in the decontamination process can be clarified and studied.

2. Experimental Methods

2.1. Chemicals

Acrylic acid (AA), butyl propionate (BA), Methyl methacrylate (MMA), potassium persulfate, sodium dodecarboxybenzene sulfonate, and OP-10 were all analytically pure and were purchased from Kelong Chemical Reagent Co., Ltd., Chengdu, China.

2.2. Synthesis

Figure 2 is the Flowchart of decontaminant preparation. Details are as follows:

(1) First, 5 g of OP-10 emulsifier was dissolved in 450 mL of distilled water and was stirred and dissolved in a 30 °C water bath. Then, 5 g of sodium dodecyl sulfate was dissolved in a clear solution containing an emulsifier and was stirred until clear. Then, 500 mL of water was added, stirred well, and set aside. Afterward, 6 g of potassium persulfate was added to the water and dissolved.

(2) We added 100 g of monomer, 100 mL of emulsifier, and 100 mL of distilled water into a beaker at room temperature, and an emulsifying machine was used for the pre-emulsification of the fluid.

(3) We added the distilled water and emulsifier into four-mouth flasks, which were each equipped with a reflux condensing tube thermometer with an agitator and a constant pressure drip funnel, and then the water was heated to 75 °C. Next, we added 100 mL of pre-emulsion and 50 mL of potassium persulfate solution. The remaining pre-emulsion was preserved in a constant pressure funnel for later use.

(4) When the emulsion was blue, the remaining pre-emulsion and potassium persulfate solution were added synchronously and slowly, which lasted 2–3 h, and then the temperature was raised to 80 °C. After 2 h of insulation, the reaction ended. Next, cooling and discharging were completed.

(5) Then, the pH value was adjusted to the desired viscosity in order to obtain the polymer substrate.

![Flowchart of decontaminant preparation](image_url)

**Figure 2.** Flowchart of decontaminant preparation.
2.3. Structural Characterization

The contact angle was tested using a surface tension tester. The temperature ranged from −10 °C to 130 °C, and the temperature control precision was 0.01 °C.

The mechanical spraying device includes the air compressor by Zhejiang Wuyi Guangli Mechanical and Electrical Co, Ltd. (Zhejiang, China).

Physical and mechanical properties of the coating include an electronic universal testing machine, namely, Qi-210, from Shanghai QING JI instrument technology Co., Ltd. (Shanghai, China). The sample was 1-mm thick, the shape was a #4 dumbbell-shaped specimen, and the tensile speed was 200 mm/min−1.

Fourier-transform infrared spectroscopy (FTIR) and nuclear magnetic resonance (1H-NMR) characterization include the chemical structures of the samples that were analyzed by (FTIR) (Nicolet 5700, Thermo Fisher, New York, NJ, USA) with a KBr sampling sheet. The 1H-NMR spectra of the powder samples were obtained using an Avanceow 600 spectrometer with D2O as the solvent.

During particle size analysis, the test was carried out using a Malvern 3000 HS nanoparticle size and potential analyzer. The sample was diluted in a measuring cup with deionized water and placed in the sample tank for testing. The test temperature was (25 ± 0.05) °C, the detection angle was 90 °C, and the laser wavelength was 633 nm.

During the film surface test, the surface of the coatings was investigated using a VHX-6000 optical microscopy system. The film was made by curing in a laboratory-made square mold (20 × 20 cm). The center area was 5 cm × 5 cm. The optical microscope system was used to switch to the depth-of-field scanning mode for membrane surface and depth testing.

The membrane cross-section included frozen slice samples that were obtained using a Leica-cm-1520 from Beijing Qianming Gene Technology Co., Ltd. (Beijing, China), sectioned at −20 °C. The samples were fixed on the tray using a fixative, and the cross-section was faced upward.

3. Results and Discussion

3.1. Study on the Influencing Factors of the Decontamination Process

3.1.1. The Wettability of the Decontaminant

Figure 1 shows the process of decontamination, which was as follows. First, the decontaminant moistens contaminants on the object’s surface. Then, after the decontaminant has completely cured, it fixes and captures the particulates and forms a film with other parts on the surface of the object. It can typically be removed as one continuous entity. From Figure 1, it can be seen that, to complete the decontamination process, the decontaminant first needs to make contact with the decontamination object, which should have a better wettability. The contact angle is an important index used to evaluate the wettability. Generally, a contact angle of less than 60 ° indicates that it has good wettability to dust particles and is hydrophilic. On the contrary, when the contact angle is >90 °, it indicates it has poor wettability and is hydrophobic.

The wetting of decontamination objects is the first step of decontamination. By testing the contact angle between the decontaminant and the pollutant, the mutual adhesion and difficulty of the adhesion of the decontaminant and the decontamination object can be examined, and the decontaminant’s wettability to dust particles and its ability to capture pollutant particles can be described.

Figures 3 and 4 show the dynamic contact angle at different times. It can be seen from Figures 3 and 4 that the contact angle of the decontaminant we chose shows a gradually decreasing trend and achieves a stable state as time passes. The data show that the decontaminant prepared by monomer synthesis can not only adhere to the dust particles but also wet the surface of the particles in a short amount of time to form the coating. This has a strong wettability to pollutant particles and can meet the requirements of decontamination. The reason for this is that sodium dodecyl benzene sulfonate acts as an anionic surfactant during the synthesis process, and it has good surface activity, which can
effectively reduce the tension at the oil–water interface. The good wettability of the decontaminant is a prerequisite for wetting surface contaminants. Figures 3 and 4 indicate that the decontaminant has good wettability as the base material of the strippable decontaminant [18].

![Graph showing the contact angles of different monomer ratios](image)

**Figure 3.** Dynamic contact angle of different monomers’ ratio butyl acrylate (BA)/methyl acrylate (MMA)/acrylic acid (AA).

As shown in Figures 3 and 4, the contact angles of decontaminants synthesized with different monomer ratios generally show a tendency to decrease with time. The results show that the synthetically-prepared decontaminant has good wettability and can spread on the surface of the pollutant quickly after contact to complete the suppression and coverage of the pollutant. It can
effectively fix pollutants and avoid further pollutant diffusion. As the content of MMA (Methyl methacrylate) in the monomer ratio increases, the initial contact angle of polymers with different monomer ratios shows an increasing trend. The analysis of the hydrophilicity of the monomers reveals that MMA acts as a hard monomer during the synthesis process. Compared with BA (Butyl Acrylate), which is a soft monomer, it has stronger hydrophobicity, which results in a change in contact angle.

AA (acrylic acid), as a functional monomer, contains a hydrophilic carboxyl group as a side chain, which will affect the dispersion state of the polymer in the emulsion, and, thereby, affects the size of the latex particles. As the amount of AA (Acrylic acid) and the hydrophilicity of the acrylic segment both increase, the water solubility increases and the particle size decreases. However, when the amount of AA is too high, the hydrophilic segments are more likely to entangle and aggregate, which increases the particle size. Thus, the added amount is smaller.

3.1.2. Surface Morphology

Figure 5 shows scan images of different samples with different monomer ratios. These deep scan images show that, after the decontaminant has completely cured, the decontaminant remover with excellent wettability can cure on surface samples, but the thickness of the film body after curing is not uniform, which also reflects the different combination of the film body and the object surface. The surface roughness of the film and the surface leveling of the film will directly determine the bonding strength between the film and the coated device and the overall film-forming effect. Researchers have suggested that the bond strength of the film is related to its surface roughness [30], which will directly affect the adhesion strength. When the film thickness is uniform, the energy barrier at the junction with the surface of the object during film formation is low. Therefore, it is beneficial to the process of decontaminant curing. As a result, test samples can continuously form films on different surfaces and be easily stripped off. However, the latex particles will directly affect the film-forming process of the decontaminant, the decontamination process, and decontamination efficiency. Therefore, the effect of particle size on decontamination needs to be studied.

![Figure 5. Scan images of samples on different surfaces.](image_url)
3.1.3. Effect of Particle Size on the Decontamination Process

In the process of decontamination, the film-forming property and leveling property of the decontaminant can be investigated from the macroscopic angle and flatness, respectively, to evaluate the effectiveness of the decontaminant as a means of removing contaminants from the surfaces of objects. However, there is no clear explanation or related discussion regarding the combination of decontaminants and pollutants in the process of decontamination. Figure 6 shows how the latex particles affect the decontamination process for the strippable decontaminant with latex particles when using emulsion polymerization. This is a question to be considered because this is a key factor that affects the efficiency of the decontaminant. During the analysis of the interaction between latex particles and pollutants in the decontamination process, when combined with the enrichment of contaminants after the decontaminant is cured, the effect of the decontaminant on the decontamination process is analyzed to verify the role of the latex particles in the decontamination process.

Figure 6. Action mechanism of decontaminant particles and pollutants.

After completing the wetting process with the pollutant, the decontaminant will continue to interact with the pollutant. At this time, according to the decontamination object and the decontamination environment, the decontamination process can be regarded as the process of the decontaminant permeating between the pores.

The flow of decontaminants through the pores can be divided into two types: those formed on the surface of the pollutant and the object, and those formed between the pollutant and the object. The liquid flow will be affected by the capillary force when it penetrates. From Formula (1), it can be seen that the capillary force is affected by the particle size formed. A smaller latex particle radius forms a greater capillary force, which promotes the decontamination process of the decontaminant.

In Figures 7–9, we illustrate the activity of latex particles for different decontamination objects.

For insoluble nuclide compounds, according to the formation theory of colloids, insoluble nuclide compounds first attract nuclide ions that are not very soluble in water and then attract counter ions to form a diffusion layer. At this time, the latex particles form a micellar structure with the insoluble nuclide as well as attract and surround the insoluble nuclide compound and nuclide ions that are slightly soluble in water. Through the formation of colloids, the latex particles, which are the main
parts of the decontaminant, complete the process of adsorbing and aggregating with radionuclide contaminants. The subsequent period includes solvent volatilization, the random movement of latex particles, aggregation and accumulation of emulsion particles, and solidification into a film. Then, the process of fixing the contaminants in the membrane body by the decontaminant is completed.

For soluble nuclide compounds, the charge of the latex particles is involved in attracting and aggregating the nuclide. Lastly, internal and external structures similar to those of the insoluble nuclide are formed to complete the fixing process of pollutants.

**Figure 7.** The activity of decontaminant on insoluble nuclide compounds.

**Figure 8.** The activity of the decontaminant on soluble nuclide compounds.
For soluble nuclide compounds, the charge of the latex particles is involved in attracting and aggregating the nuclide. Lastly, internal and external structures similar to those of the insoluble nuclide are formed to complete the fixing process of pollutants.

**Figure 9.** The activity of the decontaminant on larger particles.

For larger particles, decontaminants rely on their own wettability and leveling to complete the infiltration of pollutants. At this time, a large amount of decontaminant exists on the surface of the larger particles, and, as the moisture evaporates, a continuous film will be formed on the surface of the larger particles. The nature of the latex particles directly affects the solidification process of the decontaminant on the surface of the object, which, in turn, affects the enrichment, aggregation, and collection results of the decontaminant on the pollutants.

Additionally, from Formula (1), it can be inferred that a smaller contact angle and surface tension are conducive to the process of capillary penetration. Consequently, better decontamination performance is expected because of the smaller contact angle and smaller surface tension in the polymer substrate. Therefore, a smaller contact angle and lower surface tension are important properties of the strippable decontaminant material.

\[ \Delta P = \frac{\gamma_1 \cos \theta_1}{r} \]  

(1)

According to the analysis of the decontamination process, the nature of the latex particles has an impact on the decontamination process and the performance of the decontaminant itself. Therefore, the following discusses the latex particles in the decontaminant prepared in this experiment.

The different monomer ratios (BA/MMA/AA).

Table 1 show the Zeta potential (mv) of different monomers’ ratio. Under different monomer ratio conditions, the zeta potential of the emulsion represents the stability of the emulsion. The more stable the emulsion system, the better the mono-dispersity of the particles, and the greater the Coulomb force between the particles. Under the same measurement conditions, it is proportional to the absolute value of the charge between the particles. If the absolute value of the charge on the particle surface is larger, then it is easier to attract nuclide particles. At the same time, in the film formation process, different particle sizes have different effects on the film formation results, which affect the final film formation results of the decontaminant.
Table 1. Zeta potential (mv) of different monomers’ ratios (BA/MMA/AA).

| Zeta Potential (mv) | The Different Monomers’ Ratios (BA/MMA/AA) |
|---------------------|-------------------------------------------|
| −43.52              | 1.1:0.8:0.1                               |
| −49.25              | 1:0.9:0.1                                 |
| −39.91              | 1:1:0.1                                   |
| −30.25              | 0.9:0.1:0.1                               |
| −29.12              | 0.8:1.1:0.1                               |

Figure 11 show the film-forming properties of different monomer ratios. As is evident from Figures 10 and 11 with the change in the monomer ratio, the decontaminant has different film-forming effects after curing. When the particle size is smaller and the particle size distribution is more concentrated, the decontaminant can have better film-forming performance, which can meet the requirements for the decontaminant’s overall film formation, pollutant enrichment, and removal effect. Researchers have suggested that the reason for this is that the process of coating film formation involves the following steps: solvent evaporation, random movement of latex particles, aggregation and accumulation of emulsion particles, and film solidification. Therefore, when the particle size is smaller, the aggregates gather more closely, which is beneficial for the interpenetration and film formation between particles [17,18].

Figure 10. Particle size distribution at different monomer ratios (butyl acrylate (BA)/methyl acrylate (MMA)/acrylic acid (AA)).

With the change in the monomer ratio, the decontaminant shows different film-forming effects after curing. When the particle size is smaller and the particle size distribution is more concentrated, the decontaminant has better film-forming performance, which can meet the requirements for the decontaminant’s overall film formation, pollutant enrichment, and removal effect.

Figure 12 shows cross-sectional view images of samples with different monomer ratios. It can be seen that, after the decontaminant has completely cured, there are differences in the coating effect of
decontaminants with different particle sizes on pollutants. The result shows that decontaminants with smaller particle sizes can better cover pollutants and have a better decontamination effect.

![Figure 11. Film-forming properties of different monomer ratios. (Visual inspection after film formation curing.)](image)

**Figure 11.** Film-forming properties of different monomer ratios. (Visual inspection after film formation curing.)

**Table 2.** Strippable performance test of samples.

| Monomer Ratio | Strippable Performance |
|---------------|------------------------|
| 1:0.9:0.1     | More than 90%          |
| 0.9:1:0.1     | More than 90%          |
| 0.8:1.1:0.1   | More than 90%          |

3.2. The Decontamination Efficiency of the Decontaminant BA/MMA/AA (1:0.9:0.1)

Decontamination efficiency is an important parameter for evaluating the decontamination effect. In order to verify the decontamination ability of the decontaminant, four pieces of 3MX3M cement floor that have been divided into 100 parts are selected, and 1 kg of finely treated SiO$_2$, starch, soil dust, fly ash, and rust is spread evenly on the cement floor surface. The decontamination efficiency was evaluated by comparing the area of residual material on the surface of the cement floor and the quality of the residual material before and after peeling.

Furthermore, by characterizing the envelope form of the pollutant after decontamination, the mechanism of action between the decontamination agent and the decontamination object is explained.

Table 2 reports the results of the strippable performance test of samples. It can be seen that the test samples can continuously form films on different surfaces with complete peeling, and the peeling strength is moderate, which can meet the overall recovery requirements. A moderate peel strength can ensure that the decontaminant has a good bonding ability with the surface of the treated object after curing and forming the film and can quickly unseal when recycling is needed.

As shown in Table 3, the decontamination efficiency of the sample is more than 90% for all pollutants. At the same time, the film can be continuously formed and completely peeled off once,
which shows that the decontaminant is effective on pollutants that are loosely bound to the surface of the material and can meet the requirements for large-area peeling.

Table 2. Performance test.

| Sample         | Peel Strength (N/M) | Stripping Degree |
|----------------|---------------------|------------------|
| Glass          | 0.562               | 100%             |
| Iron sheets    | 0.855               | 100%             |
| Plastic piece  | 0.663               | 100%             |

Table 3. Decontamination efficiency of the decontaminant.

| Pollutant          | Polluted Area (%) | Prior to Decontamination | After Decontamination | Decontamination Efficiency (%) | Film-Forming Property | Stripping Degree (%) |
|--------------------|-------------------|--------------------------|-----------------------|--------------------------------|-----------------------|---------------------|
| Refined SiO₂       | 100%              | 3%                       | 97%                   | Continuous film               | 100%                  |
| Soil dust          | 100%              | 6%                       | 94%                   | Continuous film               | 100%                  |
| Fly ash            | 100%              | 4%                       | 96%                   | Continuous film               | 100%                  |
| Starch             | 100%              | 5%                       | 95%                   | Continuous film               | 100%                  |

Figure 13 shows cross-sectional views of samples. It can be seen that, after the decontaminant has completely cured, the contaminants have integrated into the decontaminant, which becomes one whole. When the contaminants on the surface of the object are fixed by the decontaminant, leakage of the contaminants can be avoided by effectively removing the pollution and avoiding the occurrence of secondary pollution. The decontaminant can then more completely remove contaminants from the surface, which increases the efficiency of the removal process. This may be attributed to the following main factors: (1) The removal of contaminants from solid surfaces can be considered a capillary infiltration process by the decontaminant. It can be inferred that a smaller particle size will be conducive to the process of capillary penetration [31]. (2) The decontaminant has good wettability, and it is beneficial to the process of decontaminant curing. (3) The appropriate monomer ratio of the polymer imparts the coating with high hardness and flexibility after film formation [32].

Figure 13. View images of samples. Membrane cross-section: Frozen slice samples were obtained using a Leica-cm-1520 from Leica, sectioned at −20 °C. The samples were fixed on the tray using a fixative, and the cross-section was facing upward.
As an effective method of radioactive decontamination, peelable decontamination has developed rapidly. From the original research in this paper, as shown in Figure 14, we have divided the decontamination process of the decontaminant into more detailed steps. In previous studies, the decontamination process of the decontaminant was divided into the following steps: (1) the decontaminant is applied on surfaces, (2) the decontaminant is cured on surfaces, (3) after a period of time, the decontaminant solidifies on the surface and forms a whole with the contaminants, and (4) after curing, the decontaminant is removed from surfaces to remove contaminants [16,21]. The decontamination process is the key factor that affects the decontamination efficiency.

![Diagram of strippable decontaminant.](image)

Through this research, as shown in Figure 14, we divided the decontamination process as follows. In the first step, the decontaminant is applied on the surface. In the second step, the decontaminant moistens contaminants on the object’s surface. In the third step, the decontaminant infiltrates into the pores between the contaminant and the contaminated surface. As the decontaminant is spread over the pore area, the decontaminant starts to cure after some hours. As it cures, it attracts, absorbs, and binds the contaminants into the decontaminant matrix. In the fourth step, after the decontaminant has completely cured, it fixes and captures the particulates continuously and forms a film with other parts of the surface of the object. In the last step, contaminants are removed by removing the decontaminant that solidifies on the surface of the object.

By redefining the decontamination process, the influencing factors of the decontamination process of the decontaminant can be more clearly defined and can better guide the production and preparation process of the decontaminant.

Furthermore, relative to previous research [19,20], the decontamination process is redefined. We discussed the main processes experienced by the latex particles in the wetting and penetration process of the decontaminant and how they affect these processes. Through an examination of latex particles, which are the main components of the decontaminant, the mechanism of the interaction between latex particles and pollutants is proposed. The factors affecting the decontamination process of the decontaminant were studied. The effect of the decontaminant ratio on the pollutants in different monomer ratios was analyzed, and the wetting of the latex particles on the pollutants was verified by observation with an optical microscope system. Compared with the conventional method of detecting the contamination level on the surface of the object before and after the decontaminant is cured [12,15], in this study, through the observation of the fixes and captures of pollutants by the
coating, the effect of the decontaminant on pollutants is more intuitively described. A new method for evaluating the efficiency of the decontaminant is provided.

4. Conclusions

Through the research in this paper, compared with the results reported in the literature, the decontamination process of the decontaminant is divided into more detailed steps, and the wetting and penetration processes that define how the decontaminant and pollutants progress through the process of decontamination are proposed. The factors affecting the wetting and penetration properties of the decontaminant are analyzed. For example, the deterring performance and leveling performance of the decontaminant can be qualitatively explained by the size of the contact angle. Furthermore, the influencing factors of decontaminant performance on decontaminant efficiency are analyzed. Through the analysis of the decontaminant’s and pollutants’ activity, the process of the action of decontaminant particles as the main component of the decontaminant and different decontamination objects is analyzed. The factors affecting the activity of the decontaminant particles and the decontamination objects are analyzed. In contrast to the previously reported literature, for the characterization and evaluation of the decontamination effect, an optical microscope was used to characterize the coverage of the contaminants by the decontaminant. In terms of efficiency, the activity of the decontaminant and pollutants is further explained. From the results reported in the references, we conclude that the synthetic decontaminant is a good peelable decontaminant that can be used on large areas of different surfaces. In the end, the particle size will affect the process of suppressing and collecting pollutants, and should be controlled during the polymerization of the monomer in order to obtain a better particle size and distribution. At the same time, it is necessary to consider the selection of synthetic monomers and additives. For example, acrylates as hydrophobic monomers can reduce the surface tension. Then, the coating has better wettability and lower surface tension, which can facilitate the decontamination process.

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