Design, Preparation and Application of Visual Self Heating Pediatric Nursing Bottles

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Abstract: This article introduces an innovative pediatric nursing bottle that has a self heating function and is made of transparent electrode material. Its design aims to quickly heat medical milk bottles and monitor the color changes of the consumed milk in real-time during the heating process, providing more accurate data support for infant care. The preparation process involves key steps such as liquid organic silicon spin coating, plasma cleaning, silver nanowire transparent conductive film coating, square resistance adjustment, electrode introduction, liquid organic silicon coverage, and heating curing. By precisely adjusting the heating temperature and transmittance, the heating effect and transparency of the bottle can be effectively optimized, ensuring the quality and safety of baby food. This pediatric care bottle can not only be used to heat medical bottles, but also to observe the consumption of milk inside the bottle, providing important support for clinical medical work. Its rich functions and potential application prospects make it of great significance in the field of pediatric medicine. Future research and development will further improve this innovative product, bring more convenience and possibilities to infant care, and contribute to improving the level of medical care for children. The introduction of this new type of pediatric nursing bottle not only brings innovation to the medical field, but also provides new possibilities for child care. The use of its self heating function and transparent electrode materials not only improves the efficiency of heating medical milk bottles, but also realizes real-time monitoring of color changes in edible milk during the heating process, which is of great significance for infant dietary management and health monitoring.

Keywords: Self Heating Milk Bottle; Transparent Electrode; Pediatric Care; Silver Nanowire; Liquid Silicone; Visual Monitoring

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1 Introduction

Pediatric nursing is a crucial branch in the medical field, dedicated to ensuring the health and happiness of infants and young children [1-3]. At this special stage, the growth and development of infants and young children have a crucial impact on their future health [4]. As one of the main tools for feeding infants and young children, medical baby bottles play an indispensable role in pediatric care [5]. However, the traditional heating method for medical baby bottles has a series of problems [6], which pose certain challenges for the feeding of infants and the work of medical staff.

With the rapid development of medical technology and the increasing concern for children's health in society, the demand for pediatric nursing tools is constantly increasing [7]. Especially in the field of infant and toddler care, the demand for safe and convenient feeding tools among healthcare workers and parents is becoming increasingly urgent [8]. The traditional heating method for medical baby bottles has a series of problems, such as cumbersome operation, uneven heating, safety hazards, etc., which bring many challenges to pediatric nursing work and infant feeding [9, 10]. It has become crucial to devel-

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op a new type of medical milk bottle that can meet the needs of medical staff for easy operation, safety and reliability [11], and provide a good feeding experience for infants and young children. This new type of milk bottle not only needs to have fast and accurate heating function, but also should have visual characteristics, so that medical staff can clearly observe the status of the milk, ensuring the safety and effectiveness of the feeding process [12]. This new type of milk bottle not only improves the efficiency and quality of medical care, but also provides more powerful guarantees for the health and happiness of infants and young children. The development of pediatric nursing bottles with self heating function has important clinical significance [13]. This is not only a challenge to medical technology innovation, but also a response to the urgent need to improve the quality of medical care for infants and young children. This new type of bottle will bring significant breakthroughs in the field of medical care, injecting new vitality and hope into the healthy growth of infants and young children [14, 15].

In traditional medical bottle heating methods, using a hot water bottle or microwave is the most common method [16-20]. However, these methods have a series of safety hazards and operational inconveniences, which have brought certain difficulties to medical staff and parents. Using a hot water bottle for heating requires a certain amount of preparation time, and medical staff need to prepare hot water in advance and wait for the temperature of the hot water to reach the appropriate heating temperature [21-23]. This not only increases the waiting time for heating, but also requires frequent checks of water temperature to ensure the uniformity and safety of milk heating. Due to the difficulty in accurately controlling the temperature of hot water, there is a risk of milk overheating, which may cause burns to infants and young children. Therefore, medical staff need to remain vigilant at all times. On the other hand, using a microwave to heat a bottle also poses certain challenges. Although microwave ovens have a fast heating speed, precise control of heating time is necessary to avoid uneven heating of milk or high temperatures. Inappropriate heating time may cause hot spots in the milk, resulting in oral burns or loss of food nutrients in infants and young children. In addition, microwave heating also has the problem of uneven distribution of microwave energy, which can easily lead to uneven milk temperature and affect feeding efficiency [24-29]. These operational inconveniences and safety hazards have placed an additional burden on the work of medical staff and posed risks to the feeding of infants and young children. Therefore, developing a pediatric nursing bottle with self heating function can effectively solve these problems, improve feeding efficiency and safety, and has important clinical significance and practical value.

In order to solve the problems of traditional medical bottle heating methods, scientists have begun to develop a new type of pediatric nursing bottle, which has self heating function and can achieve fast, safe, and visual heating process. This new type of milk bottle not only reduces the workload of medical staff and improves work efficiency, but also provides a more comfortable and safe feeding experience for infants and young children.

In this context, our team has embarked on designing and developing an innovative pediatric nursing bottle made of transparent electrode material with a self-heating function. By precisely adjusting the heating temperature and light transmittance, our milk bottles can achieve rapid heating of the milk, and during the heating process, the color changes inside the milk can be clearly observed. This innovative milk bottle not only caters to the needs of medical staff for convenient and safe operation but also offers a more comfortable and secure feeding experience for infants and young children, with significant clinical application prospects.

In this article, we will provide a detailed introduction to the preparation process, performance characteristics, and potential clinical value of the new pediatric nursing bottle that we have designed and developed. We believe that this new type of pediatric nursing bottle will bring important innovation to the field of medical care, safeguarding the health and happiness of infants and young children.

2 Design and Preparation Methods

In order to prepare pediatric nursing bottles with self heating function, we have adopted a series of precise process steps and material selection to ensure that the final product has efficient, safe, and reliable performance. Firstly, it is necessary to choose high-quality materials as the main body of the milk bottle to ensure its high temperature and corrosion resistance characteristics. This type of material can maintain stability during the heating process, without releasing harmful substances, ensuring the safety of the milk. Meanwhile, we have designed a precise heating system, including heating elements and temperature controllers. The heating element uses efficient and fast heating materials, which can quickly heat the milk to

the desired temperature. The temperature controller can accurately monitor the temperature of the milk and adjust the heating power in a timely manner to ensure a stable and even heating process, avoiding overheating or insufficient temperature. In addition, we have designed transparent observation windows to allow medical staff and parents to clearly observe the status of the milk. This design can promptly detect any abnormalities in the milk, ensuring the safety and effectiveness of the feeding process. Through precise process steps and material selection, we have successfully prepared pediatric nursing bottles with self heating function. This type of bottle not only meets the needs of medical staff for convenient and safe operation, but also provides a good feeding experience for infants and young children, bringing a new solution for pediatric nursing work.

2.1 Material Selection

When designing pediatric nursing bottles, transparent electrode materials were first selected to ensure that the bottles have good transparency and optical performance. Common transparent electrode materials include indium tin oxide (ITO) thin films and silver nanowires. Considering the excellent conductivity and transparency of silver nanowires, as well as their relatively low preparation cost, we have chosen silver nanowires as the material for transparent conductive films.

In addition to transparent electrode materials, we also selected silicone as the main material for self-supporting transparent electrodes. Liquid silicone has excellent high temperature resistance, chemical resistance, and softness, which can effectively protect the internal structure of milk bottles and provide a good appearance surface. Its soft characteristics also help reduce collision damage to the bottle during use, and improve the durability and safety of the bottle. In addition, liquid silicone also has good biocompatibility and will not release harmful substances, ensuring the safe feeding of infants and young children in the bottle.

By selecting transparent electrode materials and liquid silicone as the main materials, our designed pediatric nursing bottle not only has good transparency and optical properties, but also excellent high temperature resistance, chemical resistance, and biocompatibility. These characteristics ensure the stability and safety of the bottle during the heating process, providing a reliable feeding tool for infants and young children, and a convenient operating experience for medical staff.

2.2 Preparation Process

2.2.1 Liquid Silicone Spin Coating and Heating Curing

Spin coating of liquid silicone on a flat substrate is one of the key steps in preparing pediatric nursing bottles. In this process, it is necessary to ensure uniform coating and smooth surface. When spin coating liquid silicone, uniform coating can be achieved by controlling the spin coating speed and time, while avoiding the generation of bubbles or uneven coating. Next, the spin coated silicone needs to be heated and cured, and the temperature and time for heating and curing need to be reasonably selected based on the characteristics of the silicone. Normally, higher temperatures and appropriate curing time can promote rapid curing of silicone, ensuring complete curing without the formation of bubbles or deformation. In this process, it is necessary to precisely control the heating temperature to avoid excessive temperature causing silica gel sintering or deformation, while ensuring sufficient curing time to ensure the stability and strength of the bottle structure, the specific preparation process is shown in Figure 1.

Figure 1 Schematic diagram of Liquid Silicone Spin Coating and Heating Curing preparation process

Through the above steps, a basic structure of liquid silicone with uniform coating and good surface quality can be effectively prepared. This lays a solid foundation for subsequent processing and assembly work, ensuring that the final product has excellent performance and reliability.

2.2.2 Plasma Cleaning

Plasma cleaning treatment on the surface of cured silicone is a very important step, which can effectively remove organic pollutants and small impurities on the surface, improve the hydrophilicity and adhesion of the surface, and prepare for subsequent coating work. Plasma

cleaning is an efficient surface treatment method that can completely remove organic residues on the surface and form a clean and activated oxide layer on the surface by utilizing the chemical reactions and physical effects generated by plasma on the surface. This surface treatment can make the silicone surface more hydrophilic, improving the adhesion and stability between the transparent conductive film and the silicone surface, the specific preparation process is shown in Figure 2.

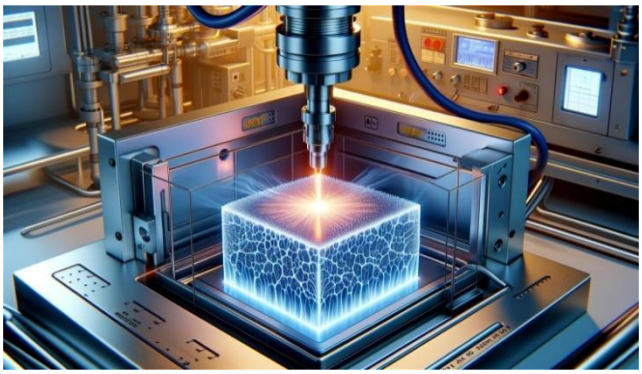

Figure 2 Schematic diagram of Plasma Cleaning

After plasma cleaning treatment, the surface of silicone should have good surface tension, which means that the coated transparent conductive film can uniformly adhere to the surface of silicone and is not prone to detachment or peeling. This lays a solid foundation for the subsequent process steps, ensuring that the final prepared pediatric nursing bottle has excellent performance and reliable quality.

2.2.3 Coating and Adjusting Block Resistance of Silver Nanowires

The spin coating process of silver nanowires on the surface of plasma cleaned silicone is one of the key steps in preparing transparent conductive films. Silver nanowires, as an excellent conductive material, can achieve good conductivity while maintaining transparency, making them very suitable for preparing transparent conductive films.

By adjusting the process parameters of spin coating silver nanowires, such as spin coating speed and spin coating times, the thickness of transparent conductive films can be effectively controlled. Usually, increasing the spin coating speed or spin coating frequency can increase the thickness of the film, thereby reducing its resistivity. This flexible adjustment method can control the resistivity of transparent conductive films according to actual needs, meeting the temperature requirements for bottle heating.

By precisely controlling the spin coating process parameters of silver nanowires, we can prepare transparent conductive films with ideal thickness and conductivity, ensuring the stability and safety of the bottle heating process. This provides reliable technical support for the preparation of pediatric nursing bottles, enabling them to exhibit excellent performance in practical applications, the specific preparation process is shown in Figure 3.

Figure 3 Schematic diagram of Coating and Adjusting Block Resistance of Silver Nanowires

2.2.4 Introducing Electrodes and Coating with Liquid Silicone Gel

One of the important steps in the preparation of milk bottles is to introduce an electrode and re coat a layer of liquid silicone on the surface of a transparent conductive film after coating silver nanowires. The purpose of this step is to ensure the structural integrity and aesthetic appearance of the bottle's outer shell, while providing additional protection and support.

The coating of liquid silicone needs to be uniform and sufficient to ensure that the entire bottle shell can be covered and there are no obvious coating defects. Uniform coating of liquid silicone can ensure the structural stability of the bottle shell and provide a good appearance surface, increasing the aesthetic and tactile comfort of the bottle. Subsequently, after coating with liquid silicone, heating and curing are required. During the heating and curing process, it is necessary to control the temperature and time to ensure that the liquid silicone gel is fully cured and tightly integrated with other parts of the bottle. Through this step, the outer shell structure of the bottle can be formed, providing a foundation for the overall performance and reliability of the bottle.

Every step in the entire preparation process is crucial, and the coating and heating curing steps of liquid silicone require precise control to ensure that the final prepared pediatric care bottle has excellent quality and performance.

2.2.5 Peel Off Transparent Electrodes and Connect Power Supply

Peel off the prepared transparent electrode from the flat substrate and connect it to the power supply. This step requires careful operation to ensure that the transparent electrode structure is not damaged, while ensuring the reliability and stability of the connection. When peeling off the transparent electrode, appropriate tools and methods need to be used to ensure that the transparent electrode can be completely separated from the flat substrate, while avoiding damage or defects. Special stripping tools or gentle stripping methods may be required to ensure the integrity and stability of the transparent electrode. Once the transparent electrode is successfully peeled off and connected to the power supply, the pediatric care bottle can start working and has self heating function. By connecting to a power source, the transparent conductive film can provide heating function when needed, thereby maintaining the temperature of the liquid in the bottle and ensuring the comfort and safety of infants while drinking milk. The entire preparation process has been carefully designed and operated to ensure that pediatric nursing bottles have excellent performance and reliable quality, which can meet the needs of infant care and provide a comfortable and safe feeding experience, The overall operation is shown in Figure 4.

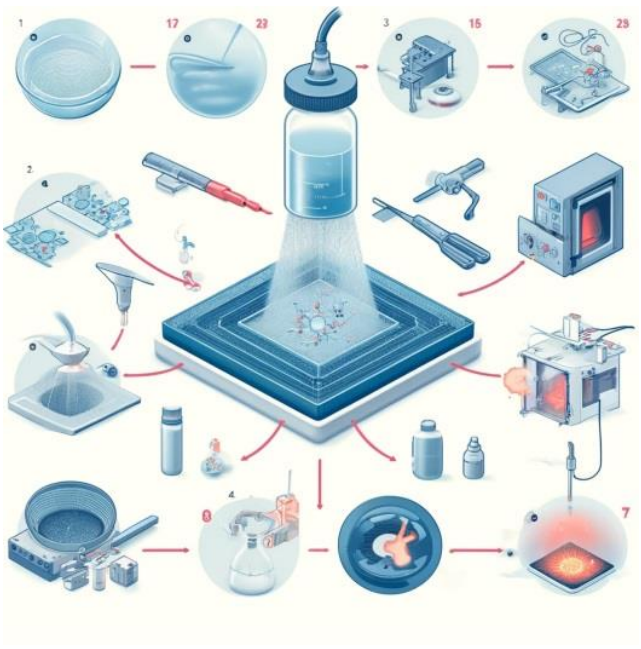

Figure 4 Schematic diagram of the overall preparation process flow

2.3 Performance Evaluation and Application

After the above preparation process, we obtained a pediatric nursing bottle with self heating function. By comprehensively evaluating its heating performance, stability, and transparency, we can ensure its reliability and safety in practical applications. At the same time, we can also apply it to medical institutions such as hospitals and children's health centers, providing medical staff with a more convenient, safe, and visual pediatric nursing tool to safeguard the health of infants and young children.

In summary, our design and preparation methods will provide important reference and inspiration for the research and development of pediatric nursing bottles, bringing new innovations and breakthroughs to the field of medical care.

3 Performance and Application

After experimental verification, the pediatric nursing bottle we prepared exhibits excellent performance and broad application prospects.

3.1 Self Heating Performance

Our pediatric nursing bottles have excellent self heating performance, which can quickly heat the edible milk inside the bottle to the desired temperature. By precisely adjusting the heating temperature and time, we can ensure that the milk is heated evenly, avoiding situations of overheating or insufficient temperature. This self heating function greatly improves the convenience of using baby bottles, allowing medical staff to feed infants and young children more efficiently and reducing safety hazards during operation.

3.2 Transparency and Observational Performance

Pediatric nursing bottles have excellent transparency, allowing for clear observation of color changes in the milk during the heating process. This feature is of great significance for medical staff to monitor the status of milk and adjust feeding methods. By observing the color changes of milk, medical staff can promptly detect the deterioration or abnormal situation of milk, and take cor-

responding measures to ensure the health and safety of infants and young children.

3.3 Application Scenarios

3.3.1 Medical Environment

In the medical environment, the application of pediatric nursing bottles can be widely involved in pediatric wards, premature infant care rooms, intensive care units, and other scenarios, providing convenient and reliable feeding solutions for medical staff. Real time monitoring of milk status, pediatric nursing bottles can ensure that milk always maintains a suitable temperature through real-time monitoring and automatic adjustment of milk temperature. In addition, changes in the state of the milk can also be understood by observing changes in the color of the milk, and medical staff can adjust feeding plans in a timely manner based on these indicators to ensure that the child obtains the best feeding effect. Improving the work efficiency of medical staff, the self heating function of pediatric nursing bottles allows medical staff to quickly heat milk for children without the need for additional heating equipment or waiting time. This greatly improves the work efficiency of medical staff, enabling them to focus more on taking care of sick children and respond more promptly to their needs. Reducing safety hazards, traditional bottle heating methods may pose a risk of burns, especially for special groups such as premature infants, where safety is particularly important. The self heating function of pediatric nursing bottles can effectively reduce the risk of burns and provide a safer feeding environment for children. Personalized feeding plan, medical staff can develop personalized feeding plans based on the specific situation and needs of the child. By adjusting parameters such as milk temperature and feeding frequency, it is possible to meet the needs of different children and promote their healthy growth. Improving the experience of pediatric patients, the efficient heating function and convenient operation of pediatric nursing bottles can reduce discomfort caused by waiting, enhance their feeding experience, and promote their recovery and growth.

3.3.2 Home Environment

In the home environment, pediatric nursing bottles with self heating function and transparent observation windows will bring great convenience and comfort to parents. In terms of convenient and fast feeding experience, parents do not need to rely on external heating devices. They can quickly heat the milk to the appropriate temperature by simply operating the bottle. This greatly simplifies the feeding process, allowing parents to more conveniently meet the feeding needs of their babies. Safe and reliable feeding guarantee, parents can monitor the color changes of milk at any time through transparent observation windows, ensuring the freshness and safety of milk. This real-time observation function provides parents with additional feeding guarantees, making them more confident. Suitable for various feeding scenarios, whether at home, out, or traveling, the self heating bottle can adapt to various feeding scenarios. Parents can provide warm milk for their babies anytime and anywhere without worrying about low or high temperatures. Saving time and energy, compared to traditional heating methods, using a self heating bottle can save parents time and energy. Parents can do other household chores or take care of their babies more efficiently without waiting for the milk to heat up or frequently checking the temperature. Sustainable and environmentally friendly, by using self heating bottles, parents can reduce their reliance on disposable heating appliances, thereby reducing resource consumption and waste generation, achieving sustainability and environmental friendliness in the family feeding process.

3.4 Social Significance and Prospects

Our pediatric nursing bottles not only have significant medical value, but also bring convenience and comfort to family feeding. Its launch will improve the efficiency and quality of pediatric nursing work, safeguarding the health and growth of infants and young children. In the future, we will continue to optimize the design of this bottle, improve its performance and stability, and explore a wider range of application areas, bringing more innovation and progress to the field of infant and child medical care.

In summary, our pediatric nursing bottles have good self heating performance and transparency, and are widely used in medical and home environments. They are of great significance for improving the efficiency and quality of pediatric nursing work, and also provide reliable protection for the health and growth of infants and young children.

3.5 Suggestions and Outlook

In the future, we will continue to increase our research and promotion efforts on self heating milk bottles, con-

tinuously optimize design, improve performance stability, and expand into a wider range of application areas. At the same time, we also hope to cooperate with more medical institutions and families to promote the use of self heating bottles, and provide more convenient and safer feeding methods for more infants and young children. We believe that self heating milk bottles will be widely used in the future, bringing more innovation and progress to family feeding, and providing reliable guarantees for the healthy growth of infants and young children.

4 Summary

This article introduces a pediatric nursing bottle with good self heating performance and transparency, which has shown excellent performance in experiments. This bottle can not only be widely used in medical environments, such as pediatric wards and premature infant care rooms, improving the work efficiency of medical staff and the feeding experience of children, but also suitable for home environments, providing convenient feeding tools for parents. Through its self heating function and transparent observation window, this milk bottle can quickly heat the milk to the desired temperature and clearly observe the milk status during the heating process, ensuring the safety and hygiene of feeding. The launch of this innovative product will greatly improve the experience of infant and toddler care, providing strong support for their healthy growth.

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