Building Antibacterial Banknotes by Adding Nanosilver Particles Synthesized in the Gas Phase

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Abstract

Silver particles are able to show antibacterial and antiseptic properties at the nanoscale [1,2]. These properties result from an alteration in the binding capacity of silver atoms in the nanosilver particles which enables them to kill harmful organisms through destroying their vital enzymes. Given that currency notes are one of the major sources of bacterial contamination and might be a critical factor in enteric infections and other health problems [3,4], here we propose a new method for producing antibacterial banknotes by using silver nanoparticles.

Materials and methods

In the present study, we used formaldehyde in the gas phase to incorporate silver nanoparticles into the banknote tissue in a homogenous way.

The materials and equipments used in the third method included: (1) silver nitrate, (2) ammonia, (3) formaldehyde (the reducing agent) , (4) deionized distilled water, (5) acetone, (6) a heater , (7) 3 beakers (cap., 200ml), (8) a Petri dish, (9) a banknote, divided into two halves, one of which was used as experimental and the other as control.

First, we prepared a 0.025 M solution of silver nitrate and ammonia by using deionized water, so that the following reaction could occur:

$$AgNO_3\ (s) + 2NH_3\ (l) \longrightarrow Ag(NH_3)_2NO_3\ (aq)$$

We also sprayed acetone thoroughly all over the banknote to make it clean (Only the experimental part of the banknote was involved in the procedure). Note that this action is only necessary when a used banknote is experimented, but unnecessary for new banknotes that have just been printed. Then the banknote was thoroughly impregnated with the solution of silver nitrate and ammonia by putting it into a Petri dish that contained the solution. Next, 50 ml of formaldehyde solution was poured into a beaker (cap. 200 ml) and 100 ml of distilled water was added to it. The beaker was put on a heater with a temperature of 80 degrees Celsius. Then we put an aluminum net on the beaker and put the banknote on top of it to be exposed to formaldehyde vapor so that the following reaction could take place:

$$Ag(NH_3)_3NO_3\ (aq) + H_2CO \longrightarrow Ag\downarrow + NH_3\uparrow + HCOOH\uparrow + NH_4NO_3$$

According to the reaction, formaldehyde can lead to reduction of silver in the silver nitrate and ammonia. We expected that the released silver atoms would create small nanoparticles which would be placed on the banknote and penetrate its tissue. To produce an optimal amount of silver nanoparticles, the heating was continued for 20 minutes. Among the side products of this reaction, ammonia and formic acid were quickly evaporated and did not remain on the banknote. In order to remove the NH_4NO_3, the banknote was soaked in a solution of water and acetone. Thus, after evaporation of the acetone, all side products of the reaction were eliminated and only the silver was left on the banknote. Finally, the banknote was dried.

According to our inquiry, the method used here for synthesizing nanosilver particles is novel. Also the way used for reducing silver in a solution of silver nitrate and ammonia is innovative.

Results

The scanning electron microscope (SEM) image showed that the silver particles on the banknote had a size of less than 90 nanometers. To examine the antibacterial property of the new product, we conducted a few challenge tests using some of the most prevalent pathogenic microorganisms (i.e., escherichia coli, staphylococcus aureus, and pseudomonas aeruginosa). In all conditions, a statistically significant higher level of antibacterial effect was observed for the treated part of the banknote in comparison with the other part. These results were obtained in spite of the very low amount of silver in the new product.

Conclusion

The proposed method can be helpful for preventing the spreading of infectious diseases, especially in countries having a high usage of banknotes. The low amount of silver used in this method ensures that it is not only economical but also safe. Note that products with a high amount of silver can be harmful for human beings [2]. The method is especially economical for higher value banknotes. Our procedure can be implemented by adding a simple device to banknote printing machines.

References

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ساخت دستگاه الکتروفورز عمودی چهار ژله با سیستم خنک کننده یخی

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چکیده:

دستگاه الکتروفورز عمودی دستگاهی است که در آزمایشگاه ها برای آنالیز بیو مولکول ها و برای جداسازی نوکلئوئیک اسید ها و پروتئین ها مورد استفاده قرار می‌گیرد.ذرات باردار توسط میدان الکتریکی برقرار شده حرکت کرده و از هم جدا می‌شوند استفاده می شود. عدم امکان بارگذاری هم زمان تعداد بالای نمونه، عدم امکان افزایش ولتاژ منبع به منظور بالا بردن سرعت آزمایش؛ بدون سیستم-های خنک کننده و هزینه بالای سیستم های خنک کننده یا ناکارآمدی آن ها در دستگاه های ایرانی و هزینه زیاد دستگاه های مشابه خارجی و حجم بالای بافر مصرفی در آن ها، موجب شد تا این گروه پژوهشی با اتصال چند قطعه پلکسی و آب بندی آن با کلروفرم، دستگاهی چهار طرفه بسازد که پس از سیم کشی و نصب فیش ها، بتواند علاوه بر امکان بارگذاری ۴۰ نمونه، گرمای حاصل از ولتاژ بالا را نیز به علت وجود محفظه فلزی حاوی ژل یخ در وسط سیستم تحمل کند. پس از طراحی دستگاه موردنظر، صفحات پلکسی در اندازه‌های متناسب با لیزر برش داده شد. پس از سوار نمودن صفحات بر روی یکدیگر و اتصال موقت آن‌ها با چسب کاغذی سیم‌ها و فیش‌ها متصل شد.و صفحات توسط کلروفرم به یکدیگر متصل و آب‌بند شدند. فضای خالی بین هر گوشه توسط چسب آکواریوم پر گردید. خطی u مانند در هر طرف برای جلوگیری از ریزش بافر تانک بالا توسط فیلمان سلیکونی ایجاد شد. شیشه‌های مخصوص ژل‌گذاری برش داده شد و با پیچ‌های تعبیه شده به دستگاه متصل گردید. مکعب مستطیلی فلزی متناسب با محفظه محصور شده توسط دستگاه، ساخته و قبل از جوش دادن ضلع آخر، درون مکعب توسط یخ ژل پر گردید. پس از تست‌های انجام شده به منظور اطمینان از آب‌بند بودن محفظه‌ها، دستگاه برای تست و مقایسه با نمونه‌های مشابه ایرانی به انستیتو پاستور ارسال شد.