Special Issue

http://dx.doi.org/10.3786/sincs2011.43

NANO-MICRO LETTERS ARTICLE

www.nmletters.org

(Proceedings of 2011 Shanghai International Nanotechnology Cooperation Symposium, SINCS 2011, Published online 10 January 2012)

# Preparation and Performance of Multifunctional Polyethylene Film

Jihu Wang, Sihao Chen, Jincheng Wang, Jiayi Tao

**Abstract:** This paper studies the multi-functional agricultural film which included antifog, diffuse reflect and insect-resistant properties. The results showed that the solution with nanometer silica sol (0.5% wt), PVA (5% wt) and DBS (0.5% wt) using as antifog agent has the smallest contact angle. Nanometer titanium, nanometer ceria and nanometer tin peroxide modified by Si-69 was added to prepared polyethylene film. The modified film had a good diffuse reflection property. The polyethylene film added 1.5%wt capsaicin has a very good mouse-resistant property.

**Keywords:** Polyethylene film; Anti-fog agent; Contact angle; Capsaicin

**Citation:** Jihu Wang, Sihao Chen, Jincheng Wang and Jiayi Tao, "Preparation and Performance of Multi-functional Polyethylene Film", Proceedings of Shanghai International Nanotechnology Cooperation Symposium, 186-189 (2011). http://dx.doi.org/10.3786/sincs2011.43

## Introduction

Plastic film has been widely used in agriculture, which can increase grain output. However, the temperature and the moisture inside the film were higher than outside especially in the morning which will lead scattering of sunlight and the energy can not be absorbed by plants. Hot water drip will scald seedlings and reduce the production of crops. Furthermore films will face the threat of rats. Therefore, multi-functional agricultural film preparation is necessary [1-4].

## Experimental

### Materials

Nanometer titanium, nanometer ceria and nanometer tin peroxide was provided by Aladdin-reagent Co. Ltd., China. Nanometer silica sol was manufactured by Zhejiang yuda chemical Co., LTD. Si-69 was supplied by Nanjing Shuguang Chemical Group Co., LTD. Polyvinyl Alcohol (PVA), sodium dodecyl sulfate (SDS), Dodecylbenzenesulfonic acid sodium (SDBS) and Triton X-100 were chemically pure from Sinopharm Chemical Reagent Co., Ltd. Low density polyethylene (LDPE) was obtained from Sinopec Group. Capsaicin was prepared by us.

### Sample preparation

Nanometer titanium, nanometer ceria and nanometer tin peroxide modified by Si-69 was added to polyethylene then prepared film. This film can diffuse reflectance light called addition type film. The $TiO_2$, $SnO_2$ and STC means the film contacted with nanometer titanium, nanometer tin peroxide and the composites of nanometer titanium, nanometer ceria and nanometer tin peroxide.

Nanometer ceria and nanometer silica were prepared sol and then added to PVA water solution (5% wt). This mixed solution has the function of diffuses reflectance. The surface of blank film was overlaid with diffuses reflectance solution then dried at room temperature. This film called spry film.

Capsaicin (1.5% wt) was mixed with polyethylene then prepared film. This film has a very good mouse-

College of Chemistry and Chemical engineering, Shanghai University of Engineering Science, Shanghai 201620, China
*Corresponding author. E-mail: wangjihu@163.com, haosihaosi@163.com,wjc406@263.net, tjy_2010@yahoo.com.cn

resistant property. This film called mouse-resistant film.

Nanometer silica sol, PVA water solution and surfactant included SDS, SDBS and X-100 were mixed then antifog agent was accepted. The surface of blank film was overlaid with antifog agent solution then dried at room temperature. This film called antifog film.

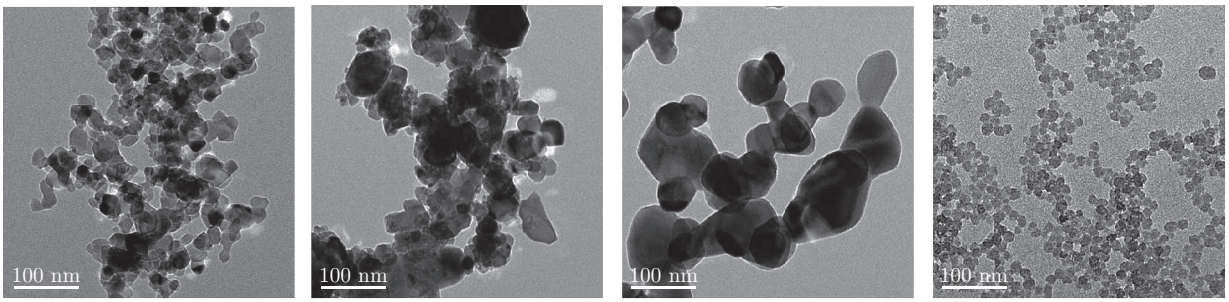
### Characterization

A JEM 2100 transmission electron microscopy (TEM) was used to study the morphology of the nanometer materials. The powder was dispersed in dilute water and then deposited on a copper grid. Light transmittance and fog level were analyzed by digital refract meter model WGW from Shanghai precision scientific instrument Co., LTD. A Perkin Elmer Lambad-950 was used to analysis light transmittance and diffuses reflectance of film. Contact angle of film was carried out by Video contact Angle meter made by Data-physics.

## Results and discussion

### TEM analysis

The TEM nanometer materials are shown in Figure 1. It can be found that the average of nanometer titanium, nanometer ceria, nanometer tin peroxide and nanometer silica sol are 25 nm, 25 nm, 60 nm and 20 nm respectively.




(a) Nanometer titanium (b) Nanometer ceria (c) Nanometer tin peroxide (d) Nanometer silica sol

Fig. 1 TEM image of nanometer materials

### Addition type diffuses reflectance film

The light transmittance and fog level of addition type diffuses reflectance film are shown in Table 1. The T% and R% are shown in Figure 2. It can be found that the light transmittance order is blank>STC>$SnO_2$ >$TiO_2$. This order is the same as T% in the figure2. As we all known, nanometer materials can absorb light so the light transmittance of film included nanometer materials declined slightly. When added nanometer materials to film, it can increased the fog level compared with blank film. The order is $TiO_2$ >STC>$SnO_2$ >blank.

**Table 1 Light transmittance and fog level of addition type diffuses reflectance film**

| Sample name | Light transmittance /% | fog level /% |
|---|---|---|
| Blank | 90.2 | 20.8 |
| $TiO_2$ | 84.0 | 50.3 |
| $SnO_2$ | 86.0 | 38.4 |
| STC | 89.4 | 48.9 |

Light transmittance is the ratio of transmitted light flux to incident light flux. Fog level is the ratio of diffuse reflection flux to transmitted light flux. The order in fog level of film is $TiO_2$ >STC > $SnO_2$ >blank, but The order in diffuse reflection of film is $TiO_2$ >STC>blank>$SnO_2$. The size of nanometer $SnO_2$ is 60 nm, but nanometer $TiO_2$ and nanometer $CeO_2$ is 25 nm. Because the size of nanometer $SnO_2$ is larger than nanometer $TiO_2$ and nanometer $CeO_2$, nanometer $SnO_2$ absorbed and dispersion the light is increased, So diffuse reflection of film is the smallest.

### Spry film

The T% and R% of spry film are shown in Figure 3. It can be found that the transmittance of spry films unchanged compared with blank film. But the reflection of spry films increased compared with blank film. The order of diffuses reflectance is 3>4>5>2, that is 2%$CeO_2$ >3 %$CeO_2$ >9%$CeO_2$ > 0.9%$CeO_2$. It can be found that with the amount of $CeO_2$ increased, diffuses reflectance increased and then declined. Nanometer $CeO_2$ has certain diffuse ability to light. When the amount of $CeO_2$ was lower, it can disperse in PVA water solution very well. With addition of the $CeO_2$, it was agglomerated in PVA water solution. So the diffuses reflectance of spry film was declined with the content of the $CeO_2$. The best amount of $CeO_2$ was 2%.

It can be found that diffuses reflectance increased when the PVA water solution included the nanometer $CeO_2$ and nanometer $SiO_2$. The order of diffuses reflectance is 9>8>7>6, that is 10%$CeO_2$ + 10%$SiO_2$ > 5%$CeO_2$ + 5%$SiO_2$ > 2%$CeO_2$ + 2%$SiO_2$ > 1%$CeO_2$ + 1%$SiO_2$.

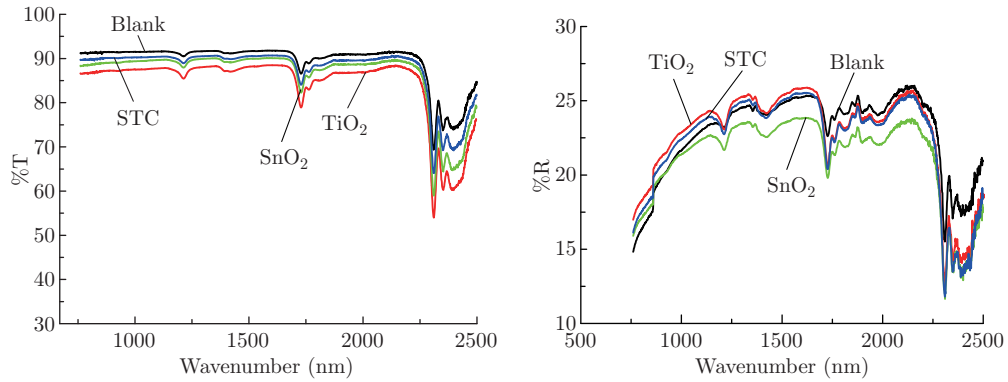



Fig. 2 T% and R% of addition type diffuses reflectance film

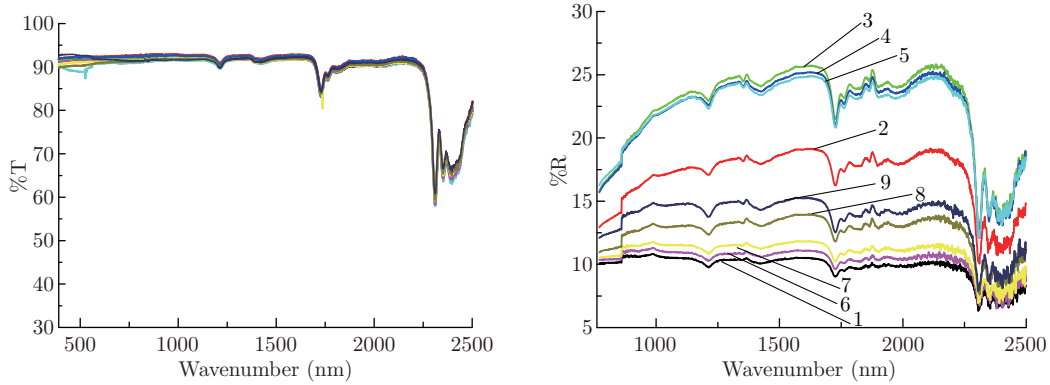



Fig. 3 T% and R% of spry film

1-blank; 2-0.9%$CeO_2$+5% PVA; 3-2%$CeO_2$+5% PVA; 4-3%$CeO_2$+5% PVA; 5-9%$CeO_2$+5% PVA; 6-1%$CeO_2$+1%$SiO_2$+5% PVA; 7-2%$CeO_2$+2%$SiO_2$+5% PVA; 8-5%$CeO_2$+5%$SiO_2$+5% PVA; 9-10%$CeO_2$+10%$SiO_2$+5%PVA

Silica surface has a hydrophile and oil functional group. It can increase the adhesive between PVA and PE. The size of nanometer silica sol is 25nm so the nanometer effect is very well. The synergy effect between nanometer $CeO_2$ and nanometer $SiO_2$ is obvious added that lead to diffuses reflectance increased.

### Mouse-resistant film

Mouse was put in the iron cage with blank film and resistant film. The weight of mouse, blank film and film included capsaicin film after 24 hours is shown in Table 2. We can find the weight of mouse and blank film is declined. But the weight of film included capsaicin can not change. When the mouse was hunger, it will gnaw the blank film. The mouse didn't gnaw the Mouse-resistant film because the Mouse-resistant film contented capsaicin. So the film included capsaicin has a very good mouse-resistant function.

**Table 2 The weight of mouse and film after 24 hours**

| 24 hours | Δ Weight/g |
|---|---|
| mouse | −1.95 |
| blank film | −0.03 |
| film included capsaicin | 0 |

### Antifog film

According to GB/T 19136-2003, ageing test of antifog film was put up. The contact angle of antifog film before and after ageing test was shown in table3. The contact angle of 1#, 2#, 8# and 9# unchanged, 5# and 7# declined , 3#, 4# and 6# increased.

The sample 1# is the PVA water solution, it can not decline after ageing test. The sample 2#, 8# and 9# is the mixed solution included PVA and nanometer silica sol. Silica surface has a hydrophile and oil functional group. It can increase the adhesive between PVA and PE. It also can not decline after ageing test.

The sample 5# and 7# is the mixed solution included PVA, nanometer silica sol and Triton X-100. Boiling point of Triton X-100 is over 270℃, it also has hydrophile and oil functional group. When the ageing test time added, the hydrophile group moved to the surface of film. So contact angle of the film declined, that is the film has a good antifog.

The sample 3#, 4# and 6# is the mixed solution included PVA, nanometer silica sol, SDS and SDBS. SDS will decompose in wet air and SDBS will decompose in hot air. When the ageing test time added, SDBS and SDS lost very quickly. The film also lost the antifog function.

**Table 3 The contact angle of antifog film before and after ageing test**

| NO. | Sample name | contact angle /° (before age) | contact angle /° (7 days) | contact angle /° (14 days) |
|---|---|---|---|---|
| 0# | blank | 81.5 | 84 | 82 |
| 1# | PVA (5%wt) | 52 | 40 | 43 |
| 2# | PVA (5%wt)+nanometer silica sol (0.5%wt) | 60.5 | 57 | 52.5 |
| 3# | PVA (5%wt)+nanometer silica sol (0.5%wt)+SDS (0.5%wt) | 13 | 84.5 | 82 |
| 4# | PVA (5%wt)+nanometer silica sol (0.5%wt)+SDBS (0.5%wt) | flat | 80 | 83.5 |
| 5# | PVA (5%wt)+nanometer silica sol (0.5%wt)+X-100 (0.5%wt) | 7 | flat | flat |
| 6# | PVA (5%wt)+nanometer silica sol (0.5%wt)+SDBS (1.5%wt) | 9 | 60 | 62.5 |
| 7# | PVA (5%wt)+nanometer silica sol (0.5%wt)+X-100 (1.5%wt) | 17 | flat | flat |
| 8# | PVA (5%wt)+nanometer silica sol (1.0%wt) | 48 | 41.5 | 40 |
| 9# | PVA (5%wt)+nanometer silica sol (1.5%wt) | 56 | 54 | 52 |

## Conclusions

The multi-functional agricultural film has antifog, diffuse reflect and insect-resistant properties functions. The film contains nanometer titanium, nanometer ceria and nanometer tin peroxide modified by Si-69 have a good diffuse reflection property. Addition type diffuses reflectance film has the best diffuses reflectance. The PVA water solution included the nanometer CeO2 2%wt has the best diffuses reflectance. The mouse-resistant film added 1.5% capsaicin has a very good mouse-resistant property. The solution with nanometer silica sol (0.5% wt), PVA (5% wt) and DBS (0.5% wt) has the smallest contact angle. The film has a persistency of antifog before and after ageing test.

## Acknowledgement

Acknowledgements: The authors thank for financial support by Shanghai “085” knowledge innovation project (JZ0904).

## References

[1] Akira Fujishima, Xintong Zhang [J]. Science, 2005, 10(6): 750-760.

[2] G. TorresDelgado, C. I. ZunigaRomero, S. A. Mayen-Hernandez, et al. Sol. Energy Mater. Sol. Cells 2009, 93: 55-59.

[3] I. A. Rahman, P. Vejayakumaran, C. S. Sipaut, et al. Cer. Int. 2008, 34: 2059-2066.

[4] F. Sayılkan, M. Asilturk, N. Kiraz, et al. Hazard. Mater. 2009, 162: 1309-1316.