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Pore Structure and Reflectivity of Light of Paper

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ABSTRACT

The pore structure of paper was modified by the application of the blending of pulp, refining, and filler particle size and ash content. It was conformed that the reflectivity of paper can be modified by the combination of the above parameters. It was also found that the change of reflectivity of paper was greatly dependent on the pore structure, such as average pore size, pore size distribution and porosity. The average pore size was decreased with addition of HwBKP, but the smallest average pore size was obtained from the addition of 80% HwBKP. Refining of pulp decreased both average pore size and the reflectivity of paper. The pore size distribution of filled paper can be varied by the combination of filler particle size and ash content

Keywords : *softwood pulp, hardwood pulp, refining, PCC, particle size, ash content, average pore size, pore size distribution, reflectivity*

1. Introduction

Various kinds of raw materials are usually introduced into the paper making process to meet the required properties of paper. A certain paper structure is obtained through the formation of network from pulp fibers and filler particles. The pulp fiber scontribute to form network structure, and the structure is filled with other additives. The pulp fibers are much longer than the thickness of the paper sheet, the network is planar and almost two dimensional. The two dimensional structure governs many paper properties, and three dimensional pore structure is important(1) because the paper structure involve the pores and voids(2). Therefore, the three dimensional structure also affects the optical properties, especially not only opacity that has very close relation with light scattering but also mechanical properties and the penetration of fluid, and determined the rheological properties during converting process.

Most of scientists and researchers had

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studied the mechanical properties which are related with runnability, surface properties which are related with printing and gloss properties, and the pore structure which is related with paper coating and converting. However, such level of studies is not enough to meet the requirements from the rapidly changing market trends and world situation. The developments of various new products using nanotechnologies are the main topic in the meeting held recently. There were lots of researches and developments using nanotechnologies, although they do not used the terminology of nanotechnology, and did not tried to improve the value and the performances. Pulp refining can change not only the average pore size but also its distribution in the paper structure(Fig. 1)(3). Jeremy Ramsden showed the possibility in the control of surface reaction, steric volume reaction, light and fluid penetration and its reaction by the combination of nanoparticles(4). Philips et al mentioned that the scattering characteristics of light can be changed by the wavelength of light and particle size(5). The previous research results showed that the pore structure of paper can be controlled by the selection and mechanical treatment of pulp, and the combination of several kinds of additives. These mean that the development of new functional products is possible by proper application of these technologies. The main purpose of this study is to investigate and gather some basic information on the effects of the combination of pulp, refining and filler loading on the pore structure and light scattering properties of paper.

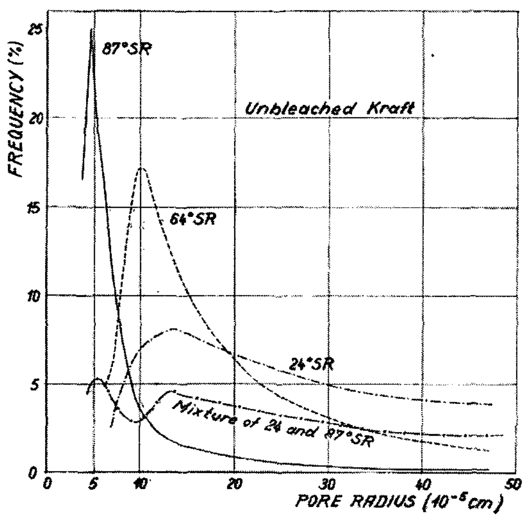

Fig. 1. Pore size distribution of papers from different beaten pulps(3).

2. Experimentals

The blending ratio of softwood bleached kraft pulp (400 ml CSF) and hardwood bleached kraft pulp (400 ml CSF), refining levels (350, 400, 450 and 500 ml CSF), particle size (0.5, 1.0 and 1.4 μm) of PCC and ash content were varied to make changes in the pore structure of paper. In the case of refining, HwBKP and SwBKP were refined separately and combined in the ratio of 8:2. Microparticle system comprised with bentonite and cationic PAM were applied to improve filler retention.

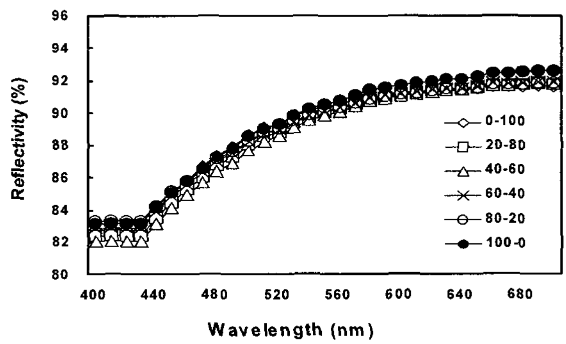

Fig. 2. Effect of HwBKP and SwBKP blending ratio on the reflectivity of paper.

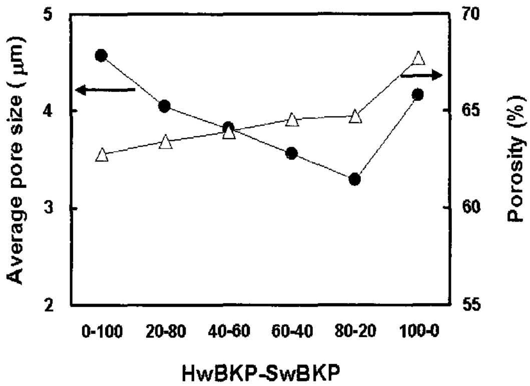

Fig. 3. Effect of HwBKP and SwBKP blending ratio on the average pore size and porosity of paper.

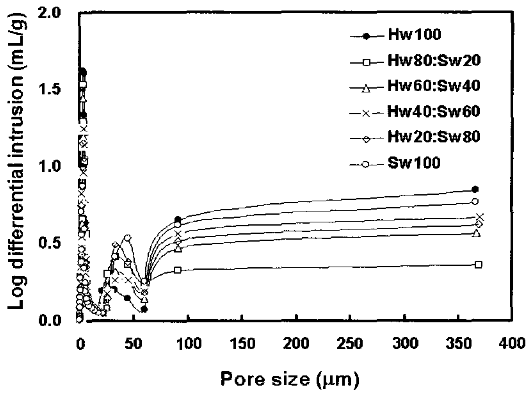

Fig. 4. Effect of HwBKP and SwBKP blending ratio on the pore size distibution of paper.

The grammage of handsheet was controlled to 80 g/m^2. Average pore size and pore size distribution for each sample were measured with Micrometric Autopore IV. The reflectivities at different wavelength of each sample were measured by the Elrepho 3000 spectrophotometer.

3. Results and Discussion

3.1 Effect of hardwood and softwood pulp blending

As one can expected, hardwood and softwood fibers have different fiber length and width. This means that different fiber should give different structural properties. The structural property has very close relation with the optical properties because it affects significantly the light scattering property of paper. Although the reflectivity of paper made from 100% HwBKP showed the highest value, but other combination showed different order due to the combination of average pore size, pore size distribution and porosity which can affect the scattering and reflection of light. Although the porosity was increased with the addition of HwBKP, but the average pore size showed the different result (Fig. 3). It was found that the pore size distribution can be controlled by the blending of different type of pulps having different fiber dimension and structural properties.

3.2 Effect of refining

Refining is most effective single means to control the paper properties including structural, mechanical and optical properties. Generally, the consolidation and density of paper are increased with refining. A matter of

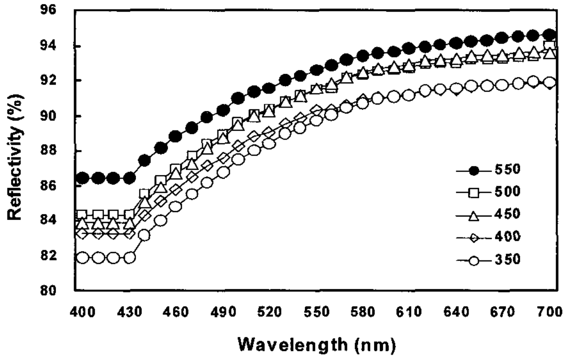

Fig. 5. Effect of refining on the reflectivity of paper.

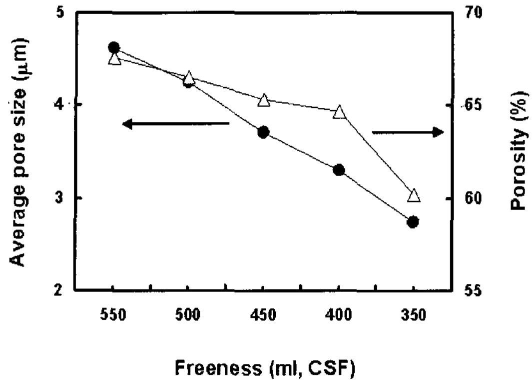

Fig. 6. Effect of refining on the average pore size and porosity of paper.

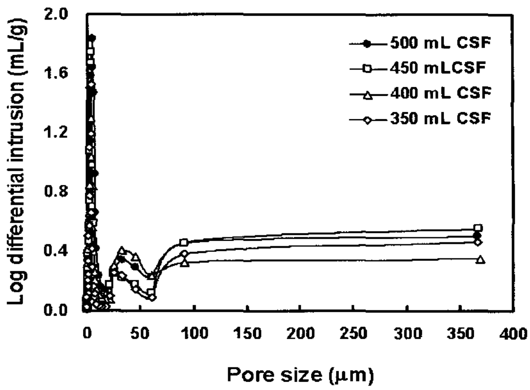

Fig. 7. Effect of refining on the pore size distribution of paper.

concern is how those properties can be controlled, and how those principles can be applied for the special purposes. As can be seen in Fig. 5 and 6, average pore size, porosity and reflectivity of light were decreased with refining. Fig. 7 showed the fact that pore volume at a certain pore size diameter can be controlled by careful refining. It also can be modified by the combination of different kinds of pulps.

3.3 Effect of filler particle size and ash content

Fillers are introduced to improve economy, opacity and printability of paper. However, if we try to approach in other point of view, we can get special characteristics. The reflectivity of paper increased with the addition of filler particles irrespective of the particle size is as expected (Figs. 8-10).

However, we could find some interesting results from Fig. 11. When the smallest filler particle(0.5 μm) was applied, average pore size was decreased with ash content. However, as the particle size increased from 0.5 μm to 1.4 μm, the average pore size was increased with ash content. This means that the particle size affects the pore size to be formed by filler

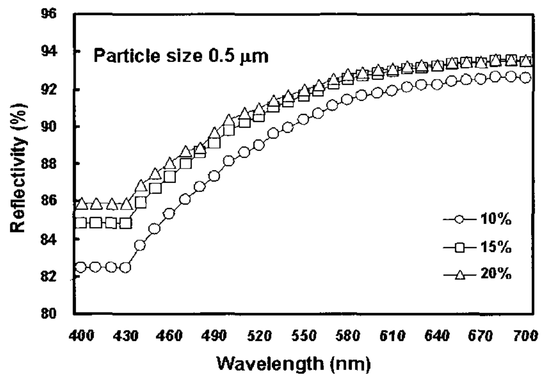

Fig. 8. Effect of ash content on the reflectivity of paper(particle size 0.5 μm).

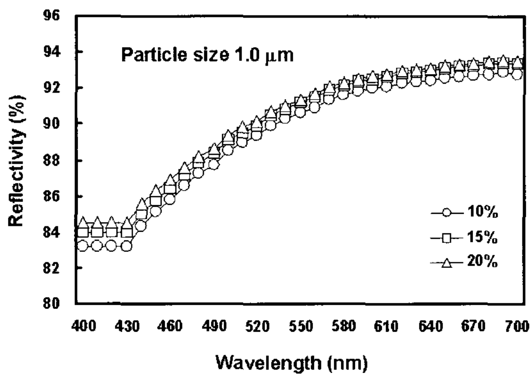

Fig. 9. Effect of ash content on the reflectivity of paper(particle size 1.0 μm).

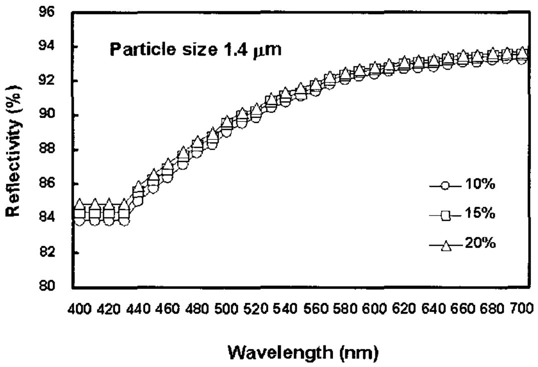

Fig. 10. Effect of ash content on the reflectivity of paper(particle size 1.4μm).

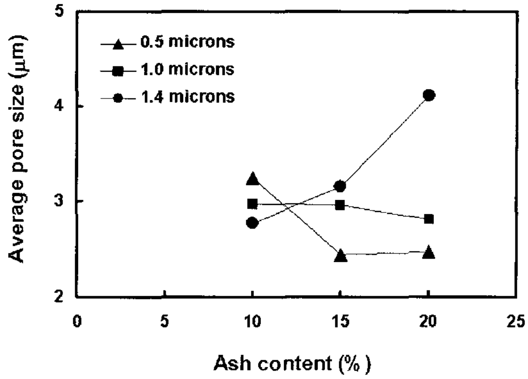

Fig. 11. Effect of particle size and ash content on the average pore size of paper.

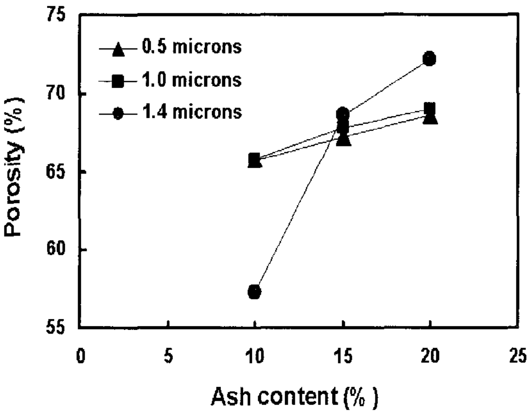

Fig. 12. Effect of particle size and ash content on the porosity of paper.

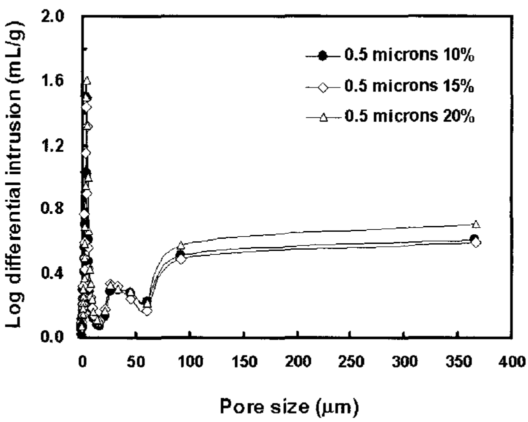

Fig. 13. Effect of ash content on the pore size distribution of paper(particle size 0.5μm).

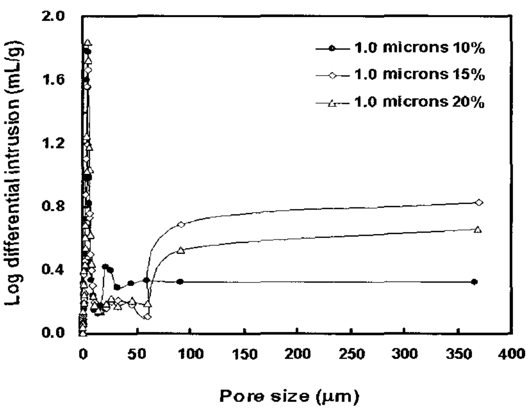

Fig. 14. Effect of ash content on the pore size distribution of paper(particle size 1.0μm).

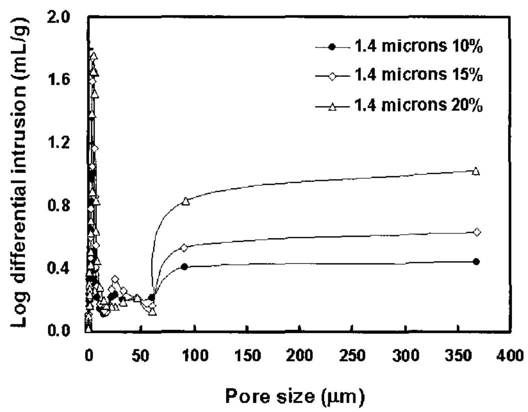

Fig. 15. Effect of ash content on the pore size distribution of paper(particle size 1.4μm).

particle and pulp fiber network. The pore structure of paper might be affected by the retention system too. However, the porosity of paper was increased with ash content whatever the filler particle size was (Fig. 12).

The pore volume obtained from PCC filled paper at a certain pore size diameter also could be varied by the combination of particle size and ash content (Figs. 13-15).

4. Conclusions

The pore structures of paper were modified by the application of the blending of pulp, refining level, filler particle size and ash content to obtain the basic information for the development of new functional paper products by the application of nanotechnology concept.

It was found that the combination of different type of pulp could modify the average pore size, pore size distribution and porosity which can affect the scattering and reflection of light. Average pore size, porosity and reflectivity of light were decreased with refining. The pore volume at a certain pore size diameter also could be controlled by careful refining. A certain average pore size obtained from the filler and pulp fiber network could be controlled by the proper combination of particle size and ash content.

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