DOI 10.1007/s11595-005-1044-z

Observation and Analysis of Gypsum Particleboard using SEM

FENG Qian[1], DENG Yuhe[1], KIM Hyunjoong[2] , LEI Wen[1]
SUN Zhiwu[1], JIA Yonggang[1],XUAN Lin[1], KIM Sumin[2]
(1.School of Mechanical and Electronic Engineereing,Nanjing Forestry University, Nanjing 210037, China;
2. Seoul National University, Seoul, Korea)

Abstract: The microstructures of gypsum board and gypsum particleboard were observed by SEM. The effects of retarder and waterproof agent on the shape and the average dimension of the gypsum crystal were discussed. The mechanism was investigated as well. Four typical instances, *i e*, the gypsum crystal shape, the gypsum combined with particles on the particles surface, the gypsum combined with particles on the wood cross section and the gypsum combined with particles inside the wood cell cavity were selected and observed. Furthermore, the agglomeration and cementation mechanism between gypsum and particle were studied.

Key words: crystal shape; gypsum particleboard; additive

1 Introduction

Compared with OSB, LVL, particleboard, medium-density fibreboard, *etc*, the gypsum particleboard with gypsum as inorganic glue possesses many better properties, for instance, no formaldehyde emission, combustion blocking off and less loss of heat exchange. Furthermore, gypsum particleboard can be processed by machinery, such as sawing, milling, polishing, *etc*. Also, the surface of gypsum particleboard is able to be retreated. So, gypsum particleboard is a new excellent environmental friendly material. The researches on gypsum particleboard began in the early 1980s [1], devoted to the raw material effect on the board property and the effect of board technology parameters, such as, wood gypsum ratio and water gypsum ratio, on the board property. The research on the microstructure of gypsum particleboard is an application-oriented research, especially on gypsum solidifying mechanism, crystal shape, the agglomeration and cementation mechanism between different lays inside the material. The initial curing of gypsum usually takes about 10 minutes; it is too short to meet the production request. To ensure two hours of initial curing time, the retarder is usually added into the gypsum. In order to improve the waterproof property, the waterproofing is also needed. The researches [2] indicated that the additive and its quantity would influence the initial curing time, coagulation process, solidify intensity and the gypsum particleboard performance. The microstructures of gypsum board and particleboard were observed by SEM in this experiment. Conclusions regarding the retarder and the waterproofing agent effects on the average gypsum crystal dimension and the aggregation shape changes were obtained.

2 Experimental

2.1 Specimens preparation

Two groups of specimens, *i e*, gypsum board and gypsum particleboard were used in this experiment. Gypsum particleboard, made in Changshan Ltd. (Shandong Province, P. R. China), was prepared in the lab as a comparing specimen.

In order to meet the SEM demand, the specimens should be made precisely according to the technology request.

2.1.1 The pure gypsum specimens

Four pieces of gypsum boards (10 mm×10 mm ×6 mm) were made in the experiment. The gypsum was ordered from Guangda Ltd. (Hunan Province, P. R. China). The retarder and the waterproofing agent were added into the gypsum board in different ratios. Four specimens were made of each gypsum board,

(Received: June 18,2005; Accepted: Sept.21,2006)

FENG Qian(冯谦): Prof.;E-mail:fq@njfu.edu.cn

Funded by the National Natural Science Foundation of China (No. 30371130) and the NSFU and KOSEF cooperation research in 2004

respectively. Images were taken by using SEM for each specimen from 500 to 10 000 times.

The specimens were prepared for the experiment with a mini-sawmill made by ourselves. The rotating speed of the saw was 1 400 rpm. The kerf milling cutter was 60 mm in diameter, 0.5 mm in thickness and with 72 teeths. The specimen dimension was 10 mm×10 mm ×6 mm.

2.1.2 The gypsum particleboard specimens

Specimens of 10 mm×300 mm×300 mm were made. The specimen density was 1.20 g/cm^3. Each specimen was weighed at a wood/gypsum ratio of 0.25 and a water/gypsum ratio of 0.35. 0.05% citric acid ($C_6H_8O_7$) was added into the gypsum as retarder. 1% and 5% organosilicon waterproof agents were applied in the test, respectively. They were mixed manually, and then water was extruded with a presser. They were dried in the hothouse until the water content reduced to 2%-3%.

2.1.3 Polishing and electrically coating

For observation, the specimen surface was rubbed out about 1 mm layer in thickness in order to dispose possible surface breakage made in preparation stage. The specimens were coated electrically by using a plasma generator (Giko IB-5).

3 Results and Discussion

3.1 SEM observation on gypsum board

Most of the gypsum board specimens were observed under an SEM(JSM-5900,JEOL),the others were observed under an SEM (505,PHILIPS). The images of the gypsum board were obtained directly. In order to get high quality images, the resolving capability should be set as 1 280×960 in the experiment.

When the image was enlarged to 1 000 times, as shown in Fig.1 (no additive were added), the gypsum crystal showed an uniform size and looked like rice. The diameter of the gypsum crystal was about 2 μm to 4 μm, and the length of most crystals was less than 5 μm, only few of crystals was 10 μm long. The gypsum crystal with 5% waterproof agent, as shown in Fig.2, was thinner and longer than the gypsum crystal without waterproof agent. The gypsum crystal was fine and uniform.

When the retarder was added into the gypsum board, as shown in Fig.3, the gypsum crystal was not uniform. More and larger crystals were observed compared to those in Fig.1 and Fig.2. The crystal length could reach 20 μm. Also, the crystal edge was blur and irregular.

Fig.4 and Fig.5 show the single gypsum crystal, the retarder and the waterproof agent were added, respectively. The images were zoomed to 10 000 times. The gypsum crystal form could be observed more clearly than those in Fig.2 and Fig.3. When the retarder was added, the crystal edge was sandwich. The crystal

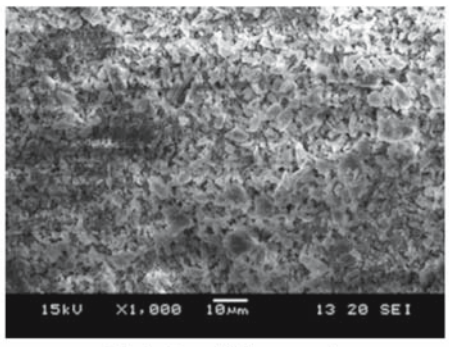


Fig.1 No additive sample

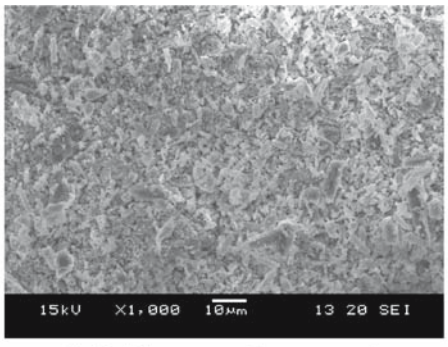
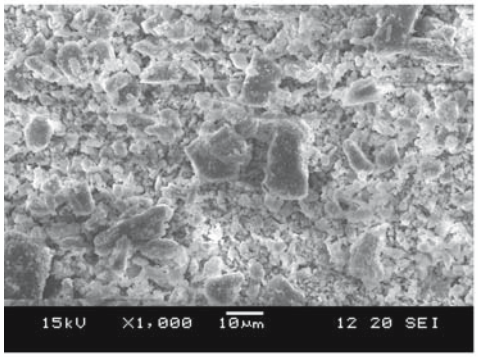
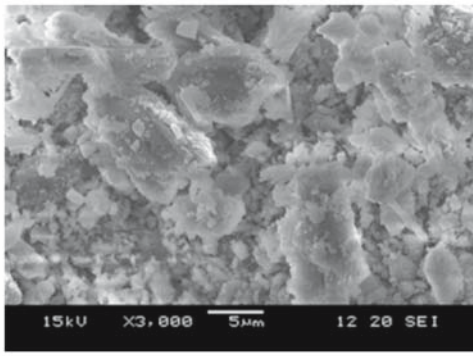


Fig.2 5% waterproof agent sample



(a) 1 000 times



(b) 3 000 times

Fig.3 Retarder added sample

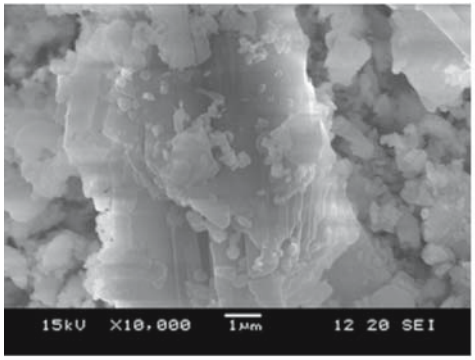


Fig.4 Retarder added sample

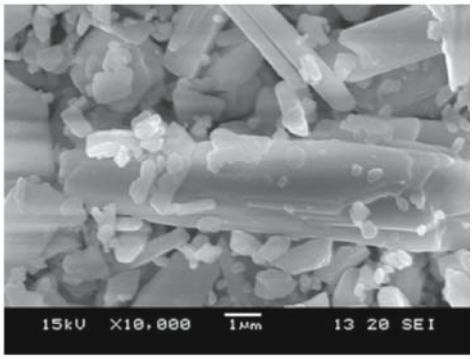


Fig.5 5% waterproof agent added sample

grew along 3D directions. The crystal was larger with an irregular shape and edge. But in Fig.5, the gypsum crystals only grew along its axes. In Fig.5, the crystals were thinner and longer, and their edges were clearer.

3.2 SEM observation on gypsum particleboard

The images of gypsum and particles should be observed by using SEM. The gypsum crystal and gypsum combined with particles in wood different section were demonstrated in Figs.6,7,8 and 9. Fig.6 shows the shape of gypsum crystal after gypsum cured. The gypsum combined with particles on the particles surface is presented in Fig.7. The gypsum combined with particles on the wood cross section is shown in Fig.8. Fig.9 shows the gypsum combined with particles inside the wood cell cavity.

In the gypsum particleboard, the gypsum crystal was floccule, which was different from the gypsum crystal in the gypsum board. Gypsum and paring were mixed, conglutinated and pressed, and then, the board was produced. Although the specimen had been burnished and polished, you could find that different

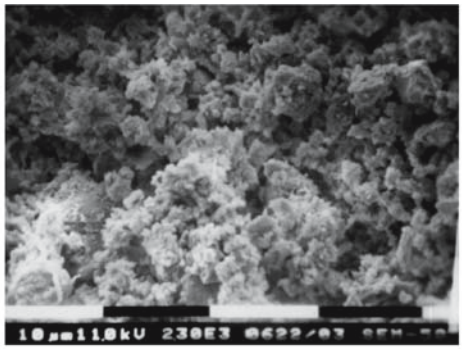


Fig.6 The shape of gypsum crystal

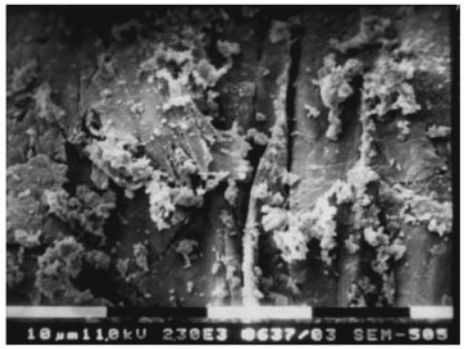


Fig.7 Gypsum combined with particles on the particles surface

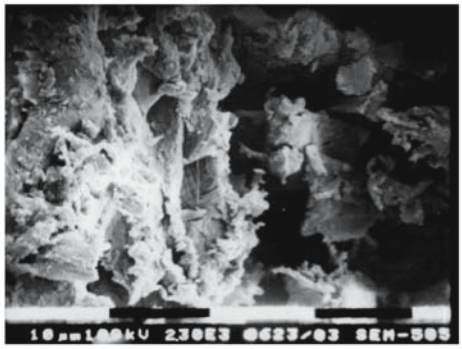


Fig.8 Gypsum combined with particles on the wood cross section

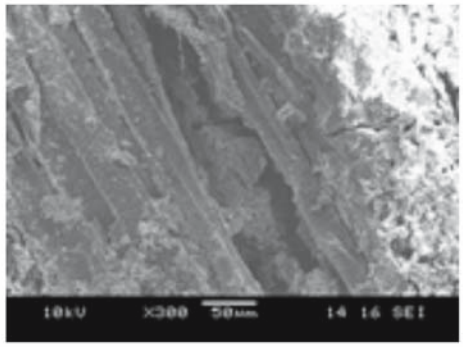


Fig.9 Gypsum combined with particles inside the wood cell cavity

gypsum crystals were cemented on the particles surface and on the wood cross section.

According to Eainger's theory [3], when the hydrate of hemihydrate gypsum was dehydrate gypsum, H^+,Sr^{2+} and Ag^+ were absorbed on the (110) crystal surface, HSO_4^-, and Na^+ on the (111) crystal surface and OH^- on the (010) crystal surface. As a result, different sorbents resulted in different crystal surface and different crystal form. When the retarder or waterproofing agent was added, the dehydrate gypsum crystal showed different forms due to different acidities when gypsum crystal built.

The initial curing time of gypsum was prolonged when the retarder was added. It resulted in bigger

and asymmetric crystals, and the length/width ratio decreased. On the other hand, crystals would grow along 3D direction and the crystal edge appeared to be blur and irregular. However, the effect of waterproofing agent was different from that of retarder. It resulted in uniform and slim crystal with clear and regular edge.

The experiments on gypsum board revealed the effects of retarder and waterproofing agent on the average dimension and the crystal shape. The retarder function, as well as its effect on the board performance was figured out. The IB was reduced obviously when more than 0.05% citric acid was added [2], but negative impacts on IB was shown when proper waterproofing agent was added [3]. Thinner gypsum crystal could improve the board strength considerably [4]. These were validated in our experiment. The experiment showed that waterproofing agent was propitious to the gypsum crystal.

When gypsum and particle were mixed and paved, the distribution and the pose of particle were random. So the following three different cases could be observed along any direction, *i e*, the gypsum crystal shape, the gypsum combined with particles on the particles surface, the gypsum combined with particles on the wood cross section and the gypsum combined with particles inside the wood cell cavity. In gypsum particleboard, gypsum crystals were floccule and adhered on to the surface and the particle section. An enough high pressure could force some gypsum crystals to adhere onto the cell wall surface in the beginning of crystal growth. At the end of crystal growth and solidification, the crystal was adhered to the wood. Gypsum crystal was arranged irregularly and the particle surface was rugate, crude and lacunaris. These would enhance the cementation intensity.

The compressive stress in gypsum particleboard production blocked the gypsum crystal growth. Therefore, gypsum crystal was floccule and no pure gypsum crystal existed.

4 Conclusions

a) The compressive stress is needed in gypsum particleboard production. With the completion of crystal growth and solidification, the crystals better adhered to the wood. Thus the compressive stress techniques are of great significance for strengthening the intensity of the material.

b) For enhancing the intensity of gypsum particleboard, some requirements are necessarily taken into consideration when selecting the buildup stuff, such as the intensity of materials, and also ruga, lacuna, roughness, and unevenness in the preparation process, for the sake of enhancing the cementation intensity.

References

[1] Y H Deng, Furuno Takeshi. Effect of Additives on Gypsum Particleboard Properties[J]. *Forestry Products Industry*, 1998, 25(2): 2-4.

[2] Y H Deng, L Xuan, Q Feng. Study on the Waterproof Property of Gypsum Particleboard Improved with Waterproofing Agent[C]. *The 7th Pacific Rim Bio-Based Composites Symposium, PROCEEDINGS*, volume II:375-382

[3] H Y Jiang, R Z Yuan, X Xiang. Research on the Hign-Strength and Water-Resistant Mechanism of Gypsum Base New Binding Material[J]. J. *Wuhan University of Technology*, 2000, 22 (1):22-24 (in Chinese)

[4] L Wu. The Retarders Effect on the Hydration Process of Calcined Gypsum and Microstructure of Gypsum[J]. *New Building Materials*, 2003(7):1-3 (in chinese)