Effect of Additives on Bactericidal Effect of ZnO Solid Solutions

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An effect of doping amount of either CaO or MnO_2 in ZnO solid solution on antibacterial characteristics was studied by conductance method and colony count method without the presence of light. ZnO-CaO solid solution powders were obtained, when CaO was added in the molar ratios (CaO/ZnO) < 0.10. In the ratios > 0.10, however, it resulted in a residual CaO in addition to the solid solution. In the case of ZnO-MnO_2 solid solution powders, a single phase was obtained in the samples mixed with the molar ratios (MnO_2/ZnO) < 0.11, but the ratios > 0.15 resulted in γ-Mn_2O_3 in addition to the solid solution. After milling the as-prepared powders by planetary ball mill, the specific surface area of these powder samples became about 10 m^2 g^{-1}, which was used in the test of growth-inhibition of bacteria (antibacterial test).
In antibacterial test of ZnO-CaO solid solution, evaluation by the conductance method revealed that the increase in the amount of CaO in solid solution resulted in a decrease in the growth inhibitory effect, i.e., bacteriostatic effect, for *Escherichia coli* and *Staphylococcus aureus*. In addition, the inhibitory effect for *Staphylococcus aureus* was found to be stronger than that for *Escherichia coli*. In the case of colony count method, the killing effect, i.e, bactericidal effect, of solid solution on *Staphylococcus aureus* markedly increased with increasing the excess CaO in solid solution, i.e., the deposition of CaO from ZnO-CaO solid solution, as shown in Fig. 1. On the other hand, the bactericidal effect of ZnO-MnO_2 solid solution was found to increase with increasing the doping amount of MnO_2 in the molar ratios < 0.11. The effect when the doping amount was > 0.15 decreased with increasing the amount of MnO_2, and was similar to that of ZnO itself; that is, the bactericidal effect was less than that of ZnO doped with MnO_2 in the molar ratios < 0.11, as shown in Fig. 2. The amount of hydrogen peroxide that contributes to the occurrence of antibacterial activity increased with increasing the doping amount of MnO_2 in the molar ratio < 0.11. In the molar ratio > 0.15, however, hydrogen peroxide was found to decrease with increasing the doping amount of MnO_2 in powder sample.

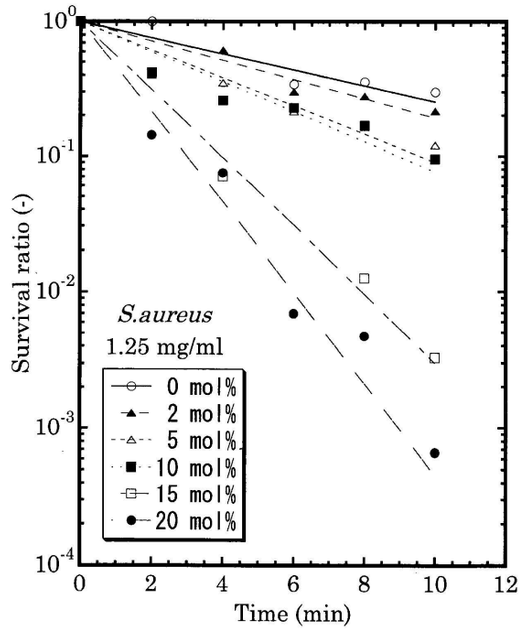

Fig. 1. *Change in survival ratio with incubation time: ZnO-CaO solid solution.*

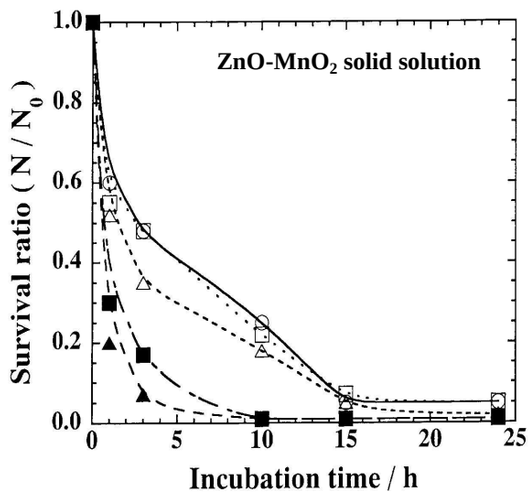

Fig. 2. *Change in survival ratio with incubation time at powder concentration of 12.5x10^{-3} g cm^{-3};* Molar ratio=□: 0.25, △: 0.15, ▲:0.11, ■: 0.053, and ○: ZnO