

11th IYPT '98
solution to the problem no. 16
presented by the team of Austria

Strange motion

Make a mixture of ammonium nitrate and water, proportion 5 to 1. When the mixture is heated to about 100°C it melts. When it cools, it crystallizes and you may observe a strange motion below the surface. Investigate and explain the phenomenon.

Safety rules: Do not heat the ammonium nitrate without water, preferably use a water bath!
Use protection glasses during the experiment!

Overview

- Experimental observations
- Possible solution
- Conclusions

1 Experimental observations

1. When you make the mixture, ammoniumnitrat-crystals and the water don't dissolve really, the crystals don't dissolve completely.
2. When the mixture is heated until 100°C , the crystals dissolve with the water so that you have a clear mixture.
3. When the mixture cools up, the clear mixture is covered at the surface with a white layer. This happens at the temperature of 90°C . The covering starts at the edge of the glass where the mixture is in, and goes on covering all the surface.
4. When the surface is already covered a second crystallizing starts at the edge of the glass and goes all over the surface until the surface is covered for a second time. This happens by a temperature of 80°C .
5. With the second crystallization structure you can observe a strange motion: From the sides of the glass water seems to come out on the crystallized surface and seems to go back under the surface. This happens about 15 times. The strange motion becomes by cooling down more and more less until 60°C are reached.
6. When the strange motion becomes more and more less, the mixture starts a third crystallization. The last one. The crystallization goes on until the mixture is already completely crystallized.
7. The crystals are brittle and white.

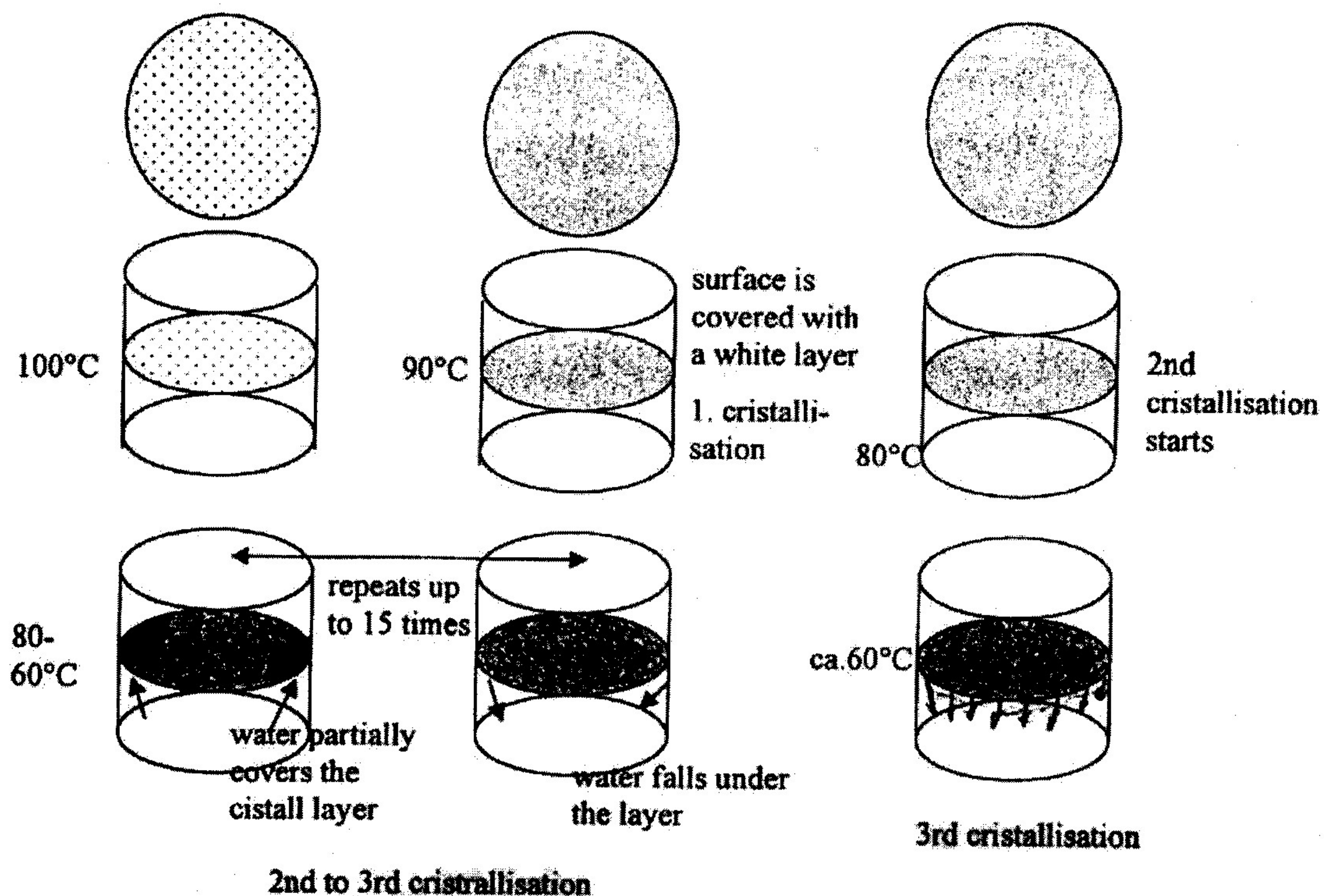


Figure 1: Strange motion, observations

2 Possible solution

The ammoniumnitrat has 5 different crystal-modifications. The different crystal-modifications are attached to the temperature, changes of crystal-modifications are connected to changes of the temperature. When the crystalstructure changes from one modification in the next one, the ammoniumnitrat-water-mixture is not stable. The stability is given when the mixture has reached a certain crystal-modification.

1. By the cooling down our first crystalstructure appears by 90°C this is a hexagonal or rhombic structure.
2. When we go on cooling down the second crystalstructure starts covering the first one by a temperature of 80°C , the structure is rhombic or monoclinic.
3. Between the second and the third crystallization it takes a longer time, and you can observe those strange motions. Probably the strange motion results of a over saturated solution. When the structure changes the condition of the mixture is no stable and reaches the condition between a over saturated and saturated solution. When the third crystallization starts the strange motion becomes more and more less probably that's because the reaction reaches a balance. The more the solution comes in a saturated and stable condition, the strange motion disappears and the third crystallization starts. When the crystallization starts the strange motion stops very fast.

3 Conclusions

So finally the problem we have is a problem of the reaction's stability. The strange motion probably results of an unstable condition between two crystalstructures.