Casting with a binary polymer in order to map ice surfaces

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Abstract

Tests were conducted with casting of a binary polymer on ice in low temperatures in order to map the ice surface. It had been noticed that the most useful casting material, Master Exact, took a long time to cure in extreme (-20C°) temperatures. Master Exact is a binary polymer made for dentistry, but is widely usaed in surface analysis. Laboratory experiments were conducted to deduce how curing time is affected by different temperatures.

1 Introduction

It is a common method to use different casting materials to replicate a surface that needs to be microscoped, but for various reasons is unable be brought into the laboratory or microscoped very well. Ice is such a surface, for many reasons. The surface structure is higly enviromentally sensitive as well as being opaque enough to be hard to measure in a microscope. The casting material we use is Master Exact, a binary putty that is mixed and applied to the surface. It does not adhere to ice, but follows the microstructure very well, Andrén and Wennström (2007).

1.1 Experiments

During field experients however, it was noticed that the material Master Exact did not harden if the temperature was below $-20\,^{\circ}$C. So we decided that curing times needed to be analyzed. Tests were conducted in different freezers set at the temperatures $20\,^{\circ}$C, $10\,^{\circ}$C, $-5\,^{\circ}$C, $-10\,^{\circ}$C and $-20\,^{\circ}$C. We allowed the unmixed binary liquid to attain the temperature of the freezer for more than an hour in each freezer before being mixed. When mixed, the material started to harden and observations were conducted at least 10 times over the period it took for the material to harden. Checkup

times was longer for the colder climates, since curing speed was so slow. The hardness of the binary liquid was evaluated according to Table 1.

Table 1: Different consistencies of the casts.

State	Description
Applied	When the substance has been applied.
Liquid	The substance was still moving over the surface.
Gooey	Sticks to the substance but still liquid.
Stringy	Threads are formed when touched, but sticks to the surface.
Gummy	The substance has some shape, but is still sticky.
Sticky	Stickiness can be felt on the surface.
Dry	The surface is dry to touch.

Using this hardness scale, the curing time could be measured with reasonable objectively. The casting material can not be removed until it has passed the Gummy stage, or it will break at removal. Time was measured from the last time the material was observed to be Sticky.

2 Results

Chemical kinetics, Atkins and de Paula (2006), is highly temperature dependent, and field observations has shown that the casting material does not harden if it is colder than $-20\,^{\circ}\mathrm{C}$. Seeing to the results we noticed that for sub zero temperatures we did follow an exponential curve according to Equation 1,

$$t(T) = 43\mathrm{e}^{0.2T} \tag{1}$$

where t is the time in minutes dependant on T, the temperature in $^{\circ}\mathrm{C}$. Table 2 gives the measured times for the different temperatures.

Table 2: The different curing times t dependent on temperature T.

Temp T ($^{\circ}\mathrm{C}$)	Time t (minutes)
$20\,^{\circ}\mathrm{C}$	5
$10\,^{\circ}\mathrm{C}$	67
$-5\,^{\circ}\mathrm{C}$	101
$-10\,^{\circ}\mathrm{C}$	273 (4.5 hours)
$-20\,^{\circ}\mathrm{C}$	1520 (25 hours)

A plot of Equation 1 together with the values can be seen in Figure 1.

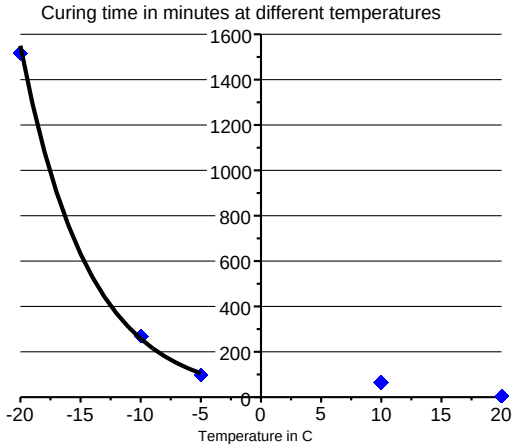

Figure 1: Plot of curing time t (y-axis) as function of temperature T (x-axis) (blue ◆), as well as the matching Equation 1 for subzero temperatures.

It is assumed that the curing time goes to infinity below $-20\,^{\circ}\mathrm{C}$ and to a few minutes at $30\,^{\circ}\mathrm{C}$.

3 Conclusion

The hardening time for the binary polymer Master Exact, casted on ice, could be modeled with an exponential function. The curing time goes to infinity below $-20\,^{\circ}\mathrm{C}$ and to about one hour and a half at $0\,^{\circ}\mathrm{C}$.

It is recommended to use some kind of moderate heating for low temperatures. The ice surface will be protected by the binary polymer and has been observed to be fairly enviromentally resistant under this surface.

4 Acknowledgement

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References

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