Use of Optical Microscopy and Image AnalysisTechniques to Study Growth and Nucleation Rate Behaviour in the Tripalmitin/Tristearin Binary System

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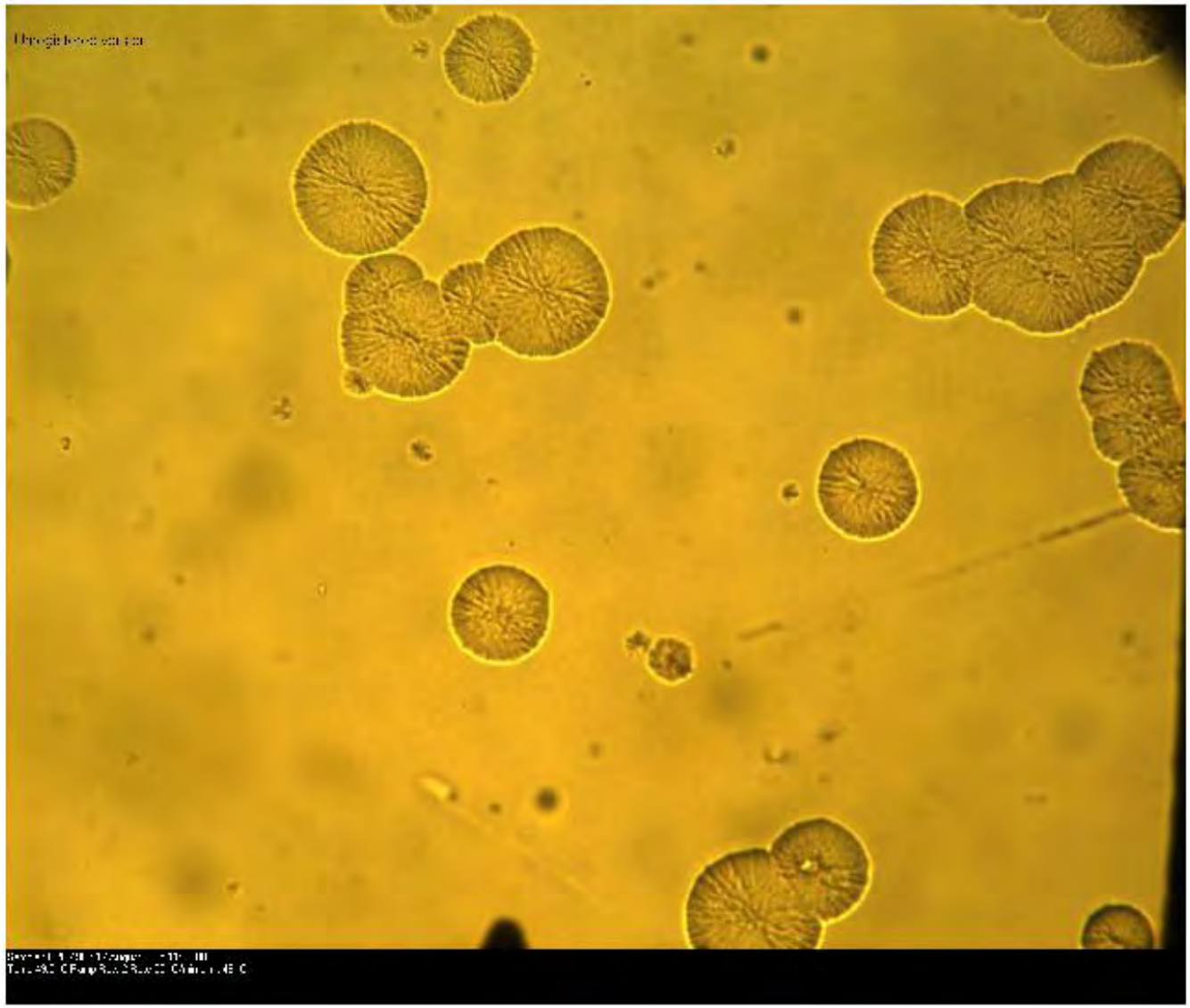
Overview – Methods for studying fat crystallisation

- Differential scanning calorimetry
- X-ray diffraction
  - Hi res synchrotron
  - Low res
- NMR
- Ultrasound
- Optical microscopy

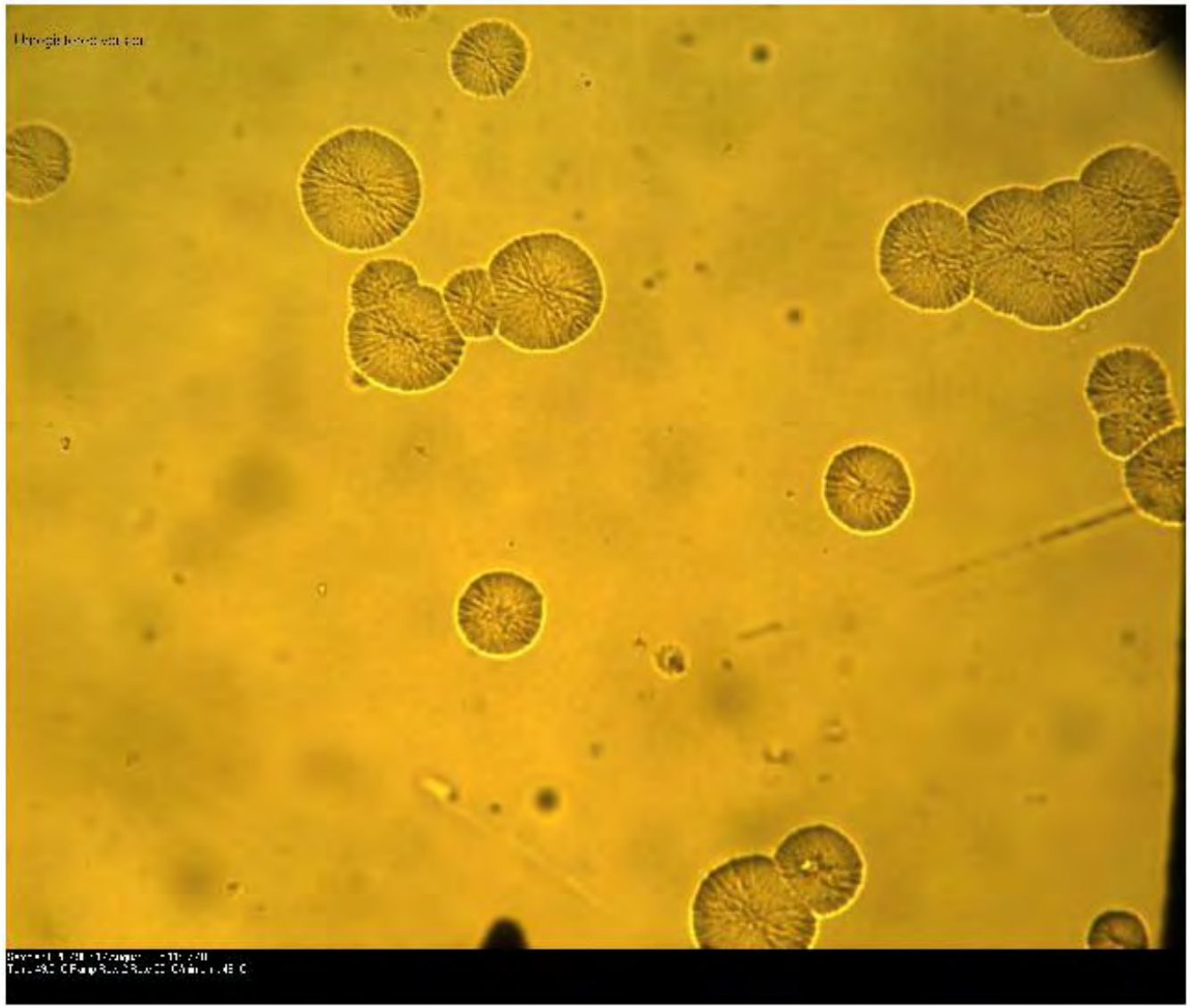
Tripalmitin (PPP) at 49°C

(1.75 x 1.5 mm; speeded up x50)

How to analyse?

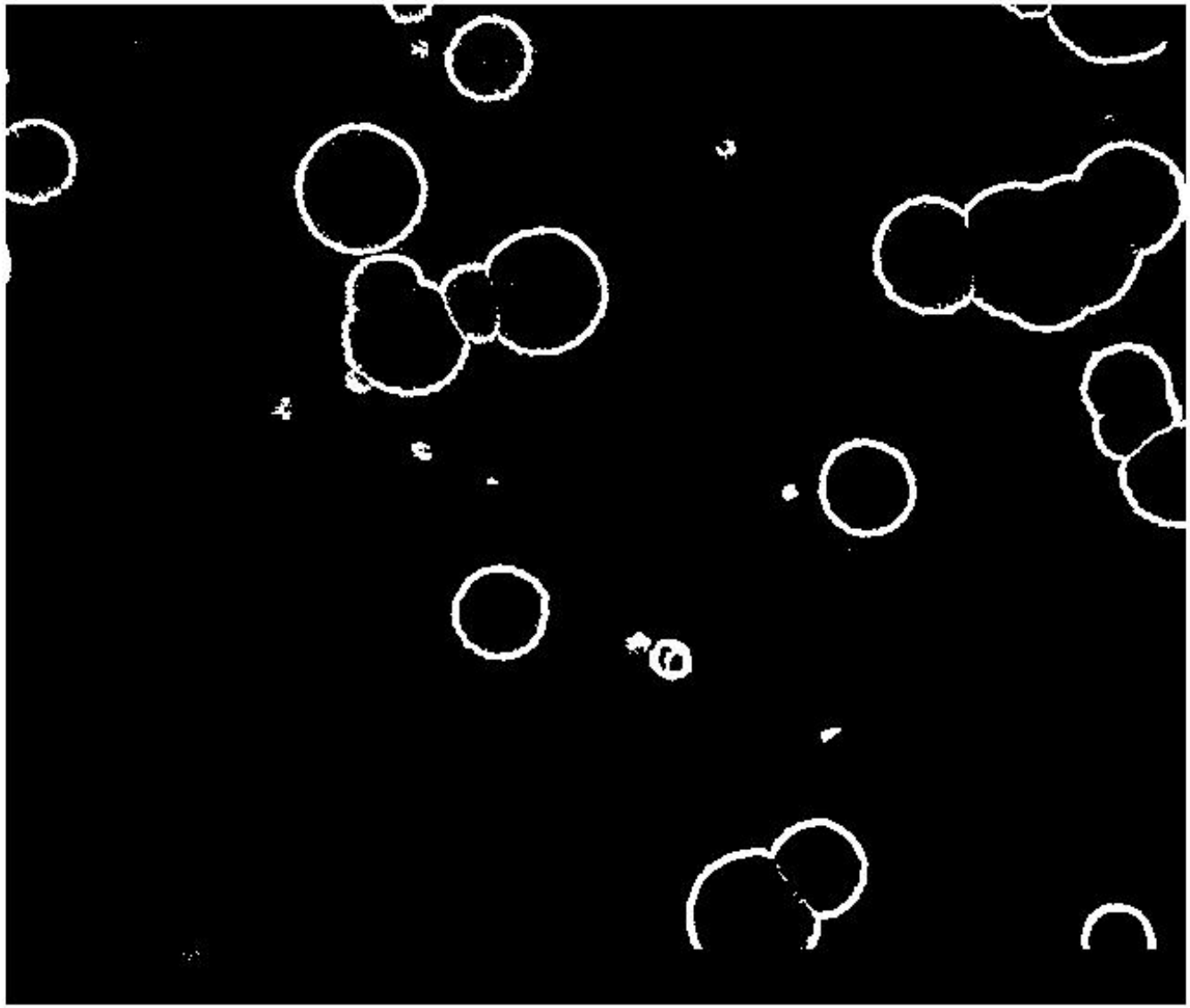


Take previous image…

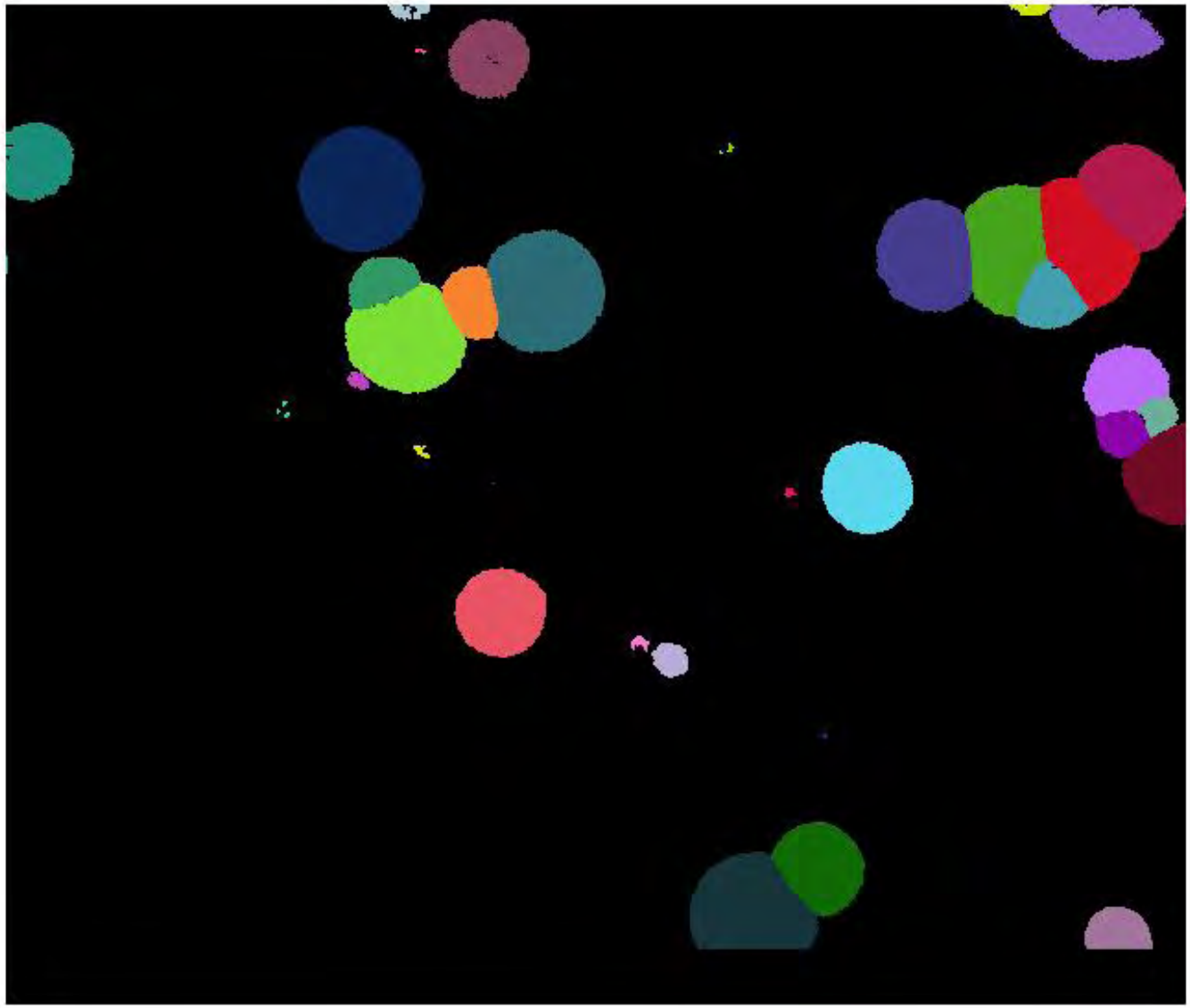


…and subtract

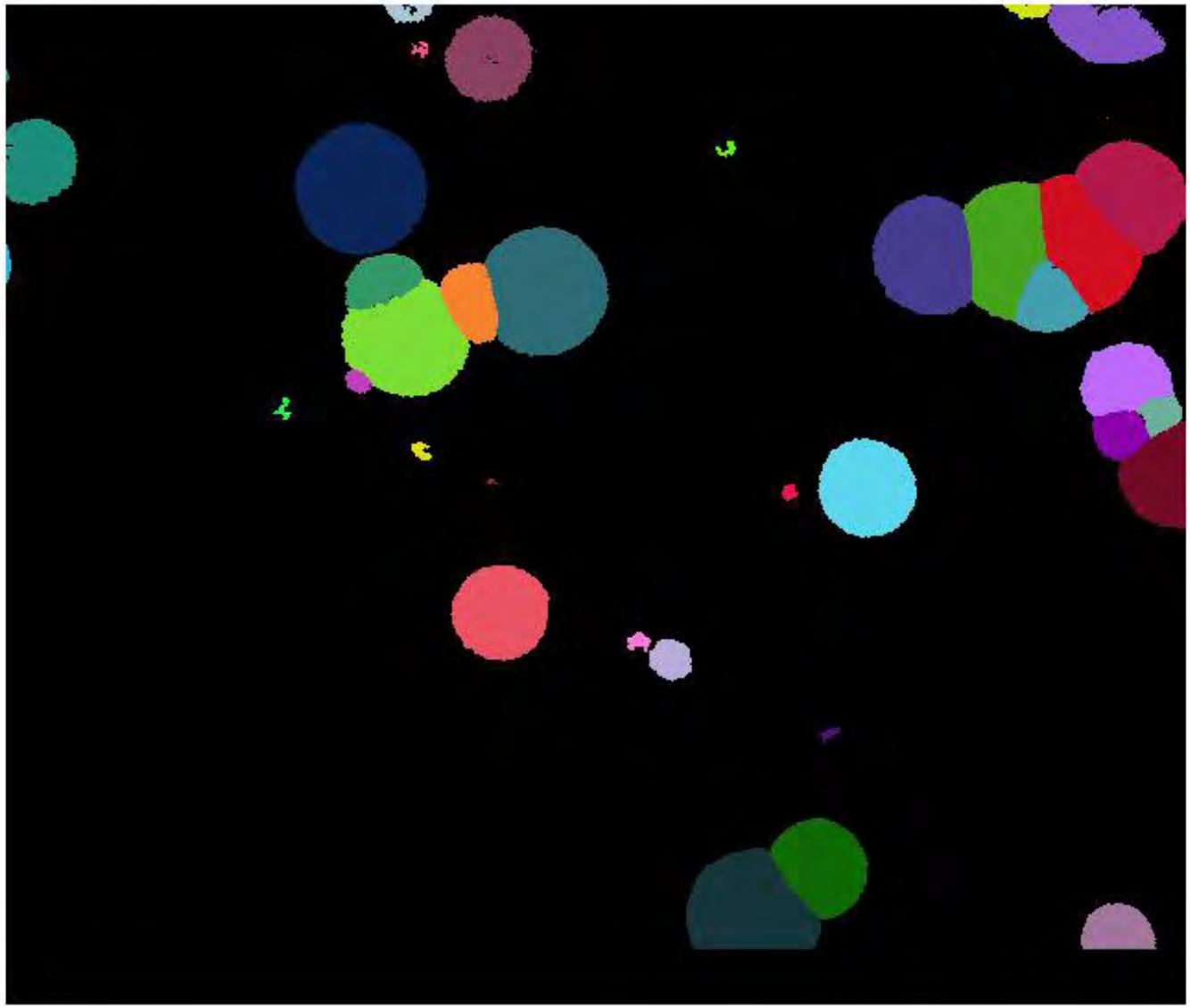
Threshold → Binary map



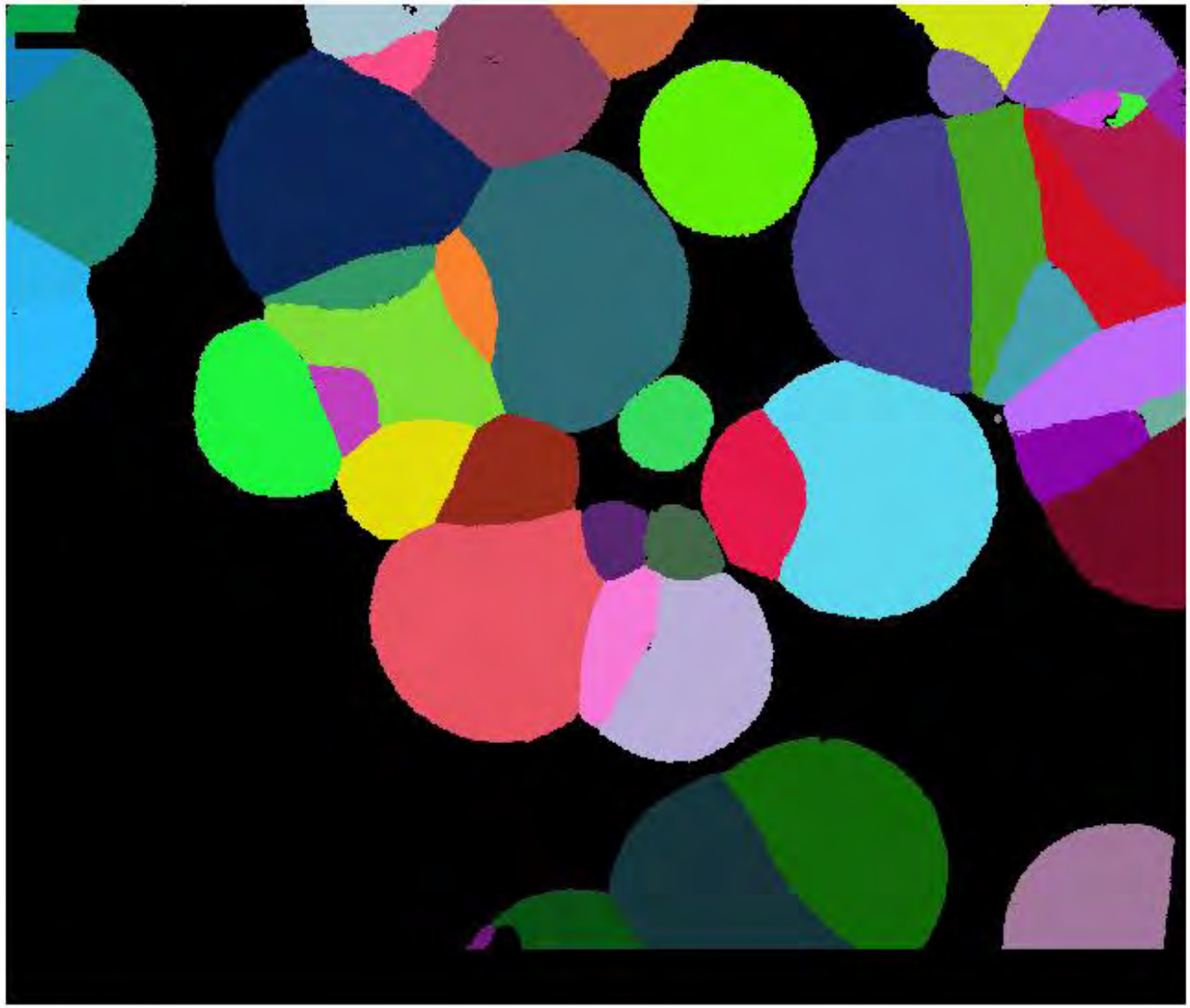
Build up “crystal maps” (previous image)



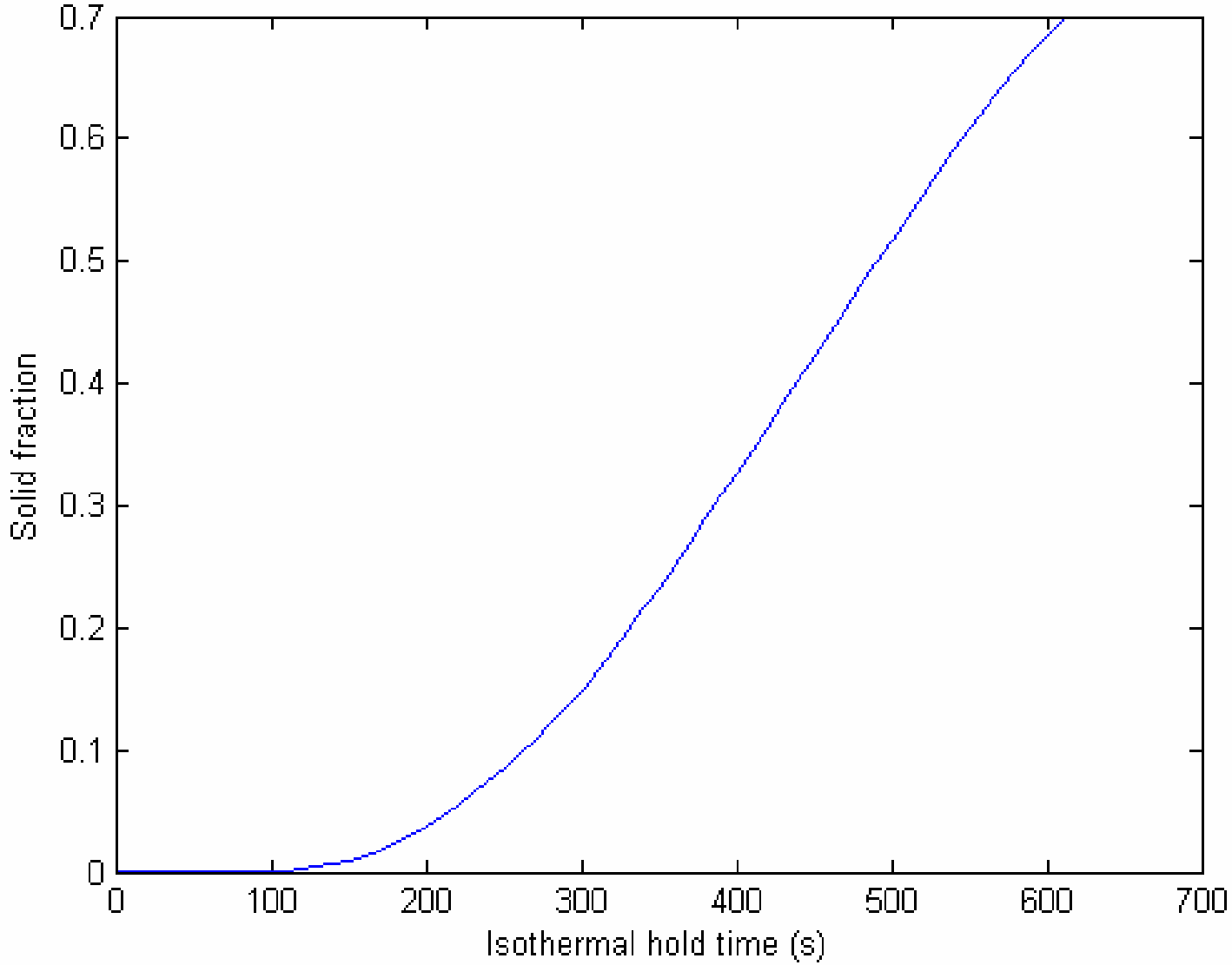
Produced updated “crystal map”



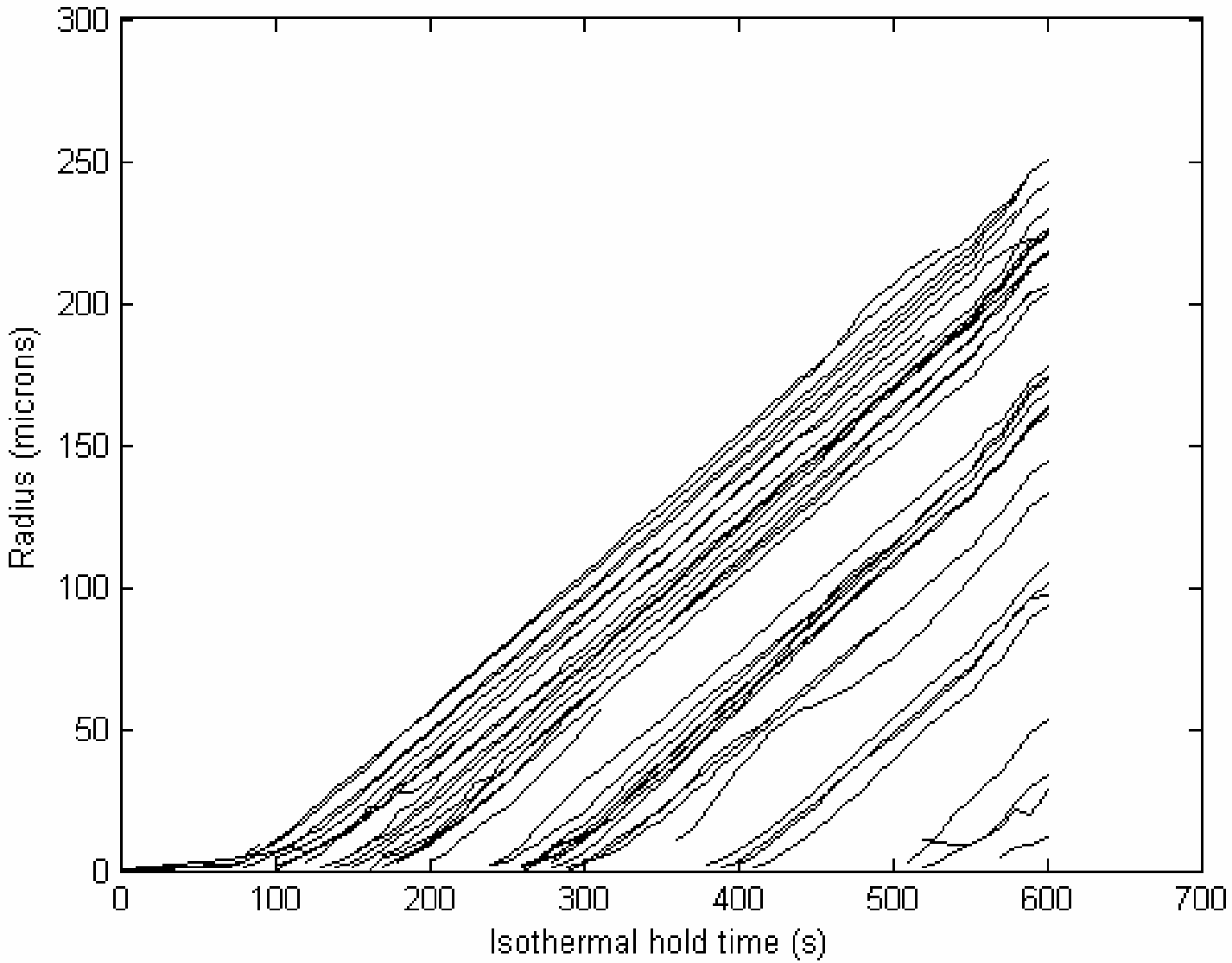
Tripalmitin (PPP) at 49°C



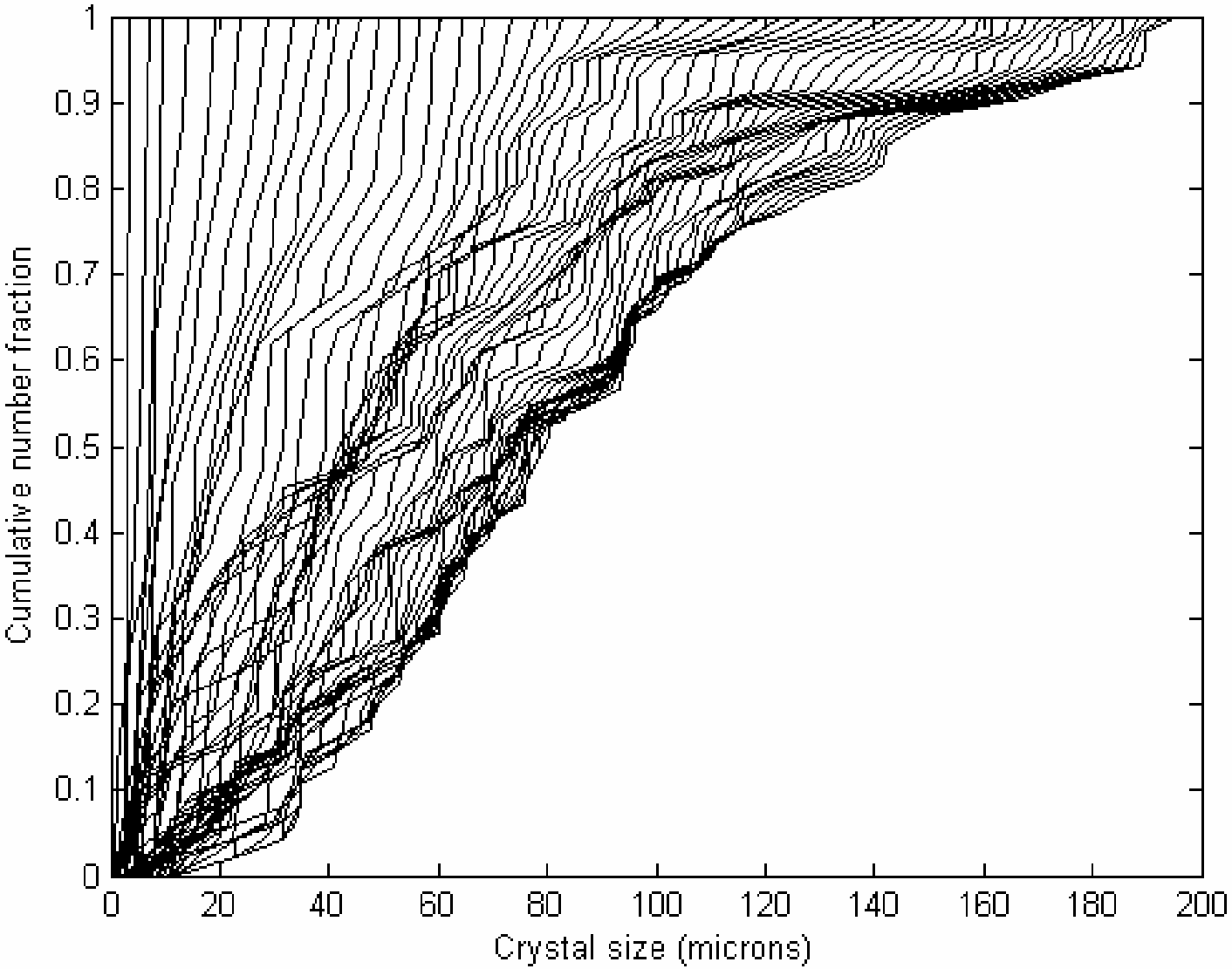
Solid fraction (PPP @ 49°C)



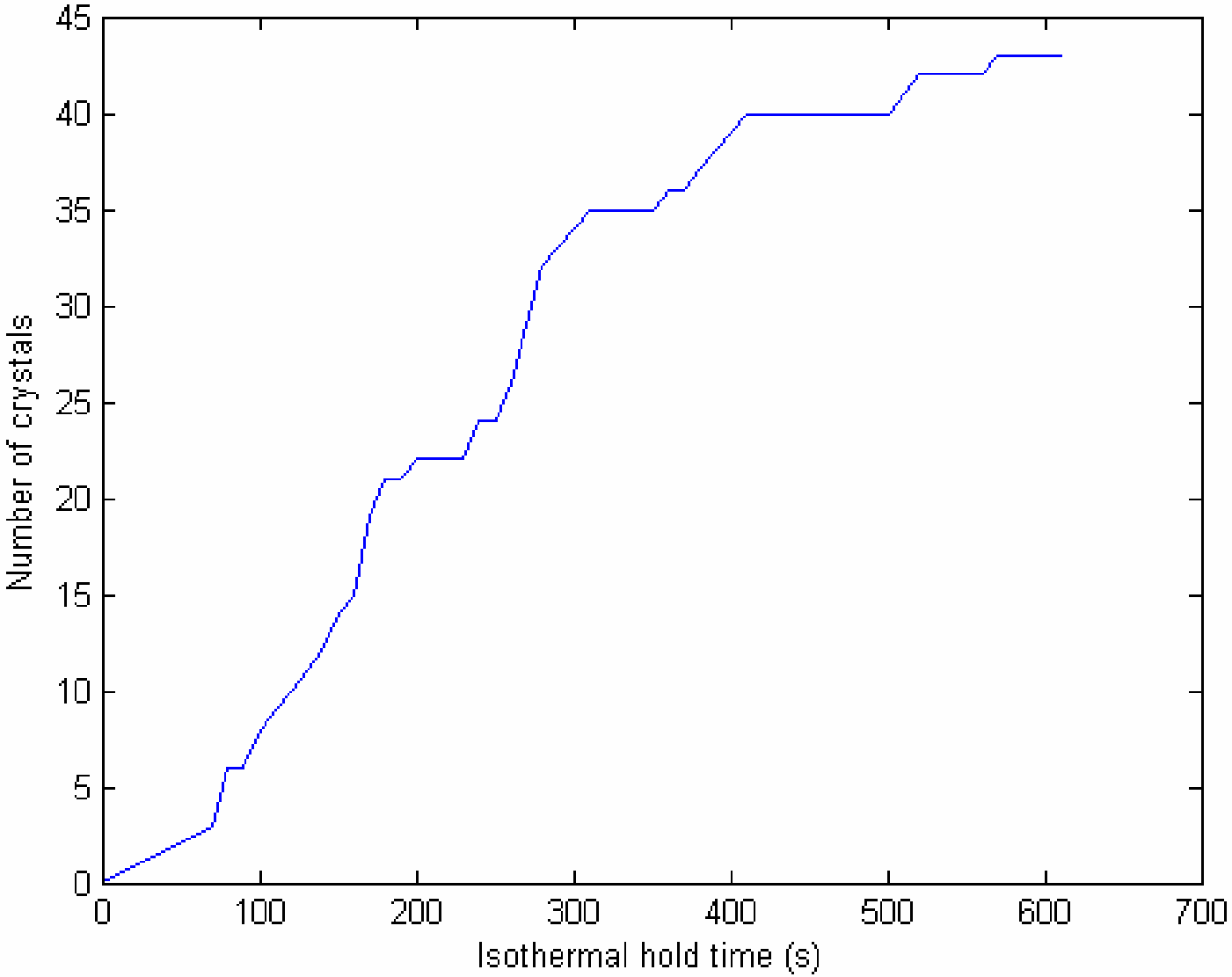
Radius vs time (PPP @ 49°C)



Cumulative size distribution (PPP @ 49°C)



No. crystals vs time (PPP @ 49°C)

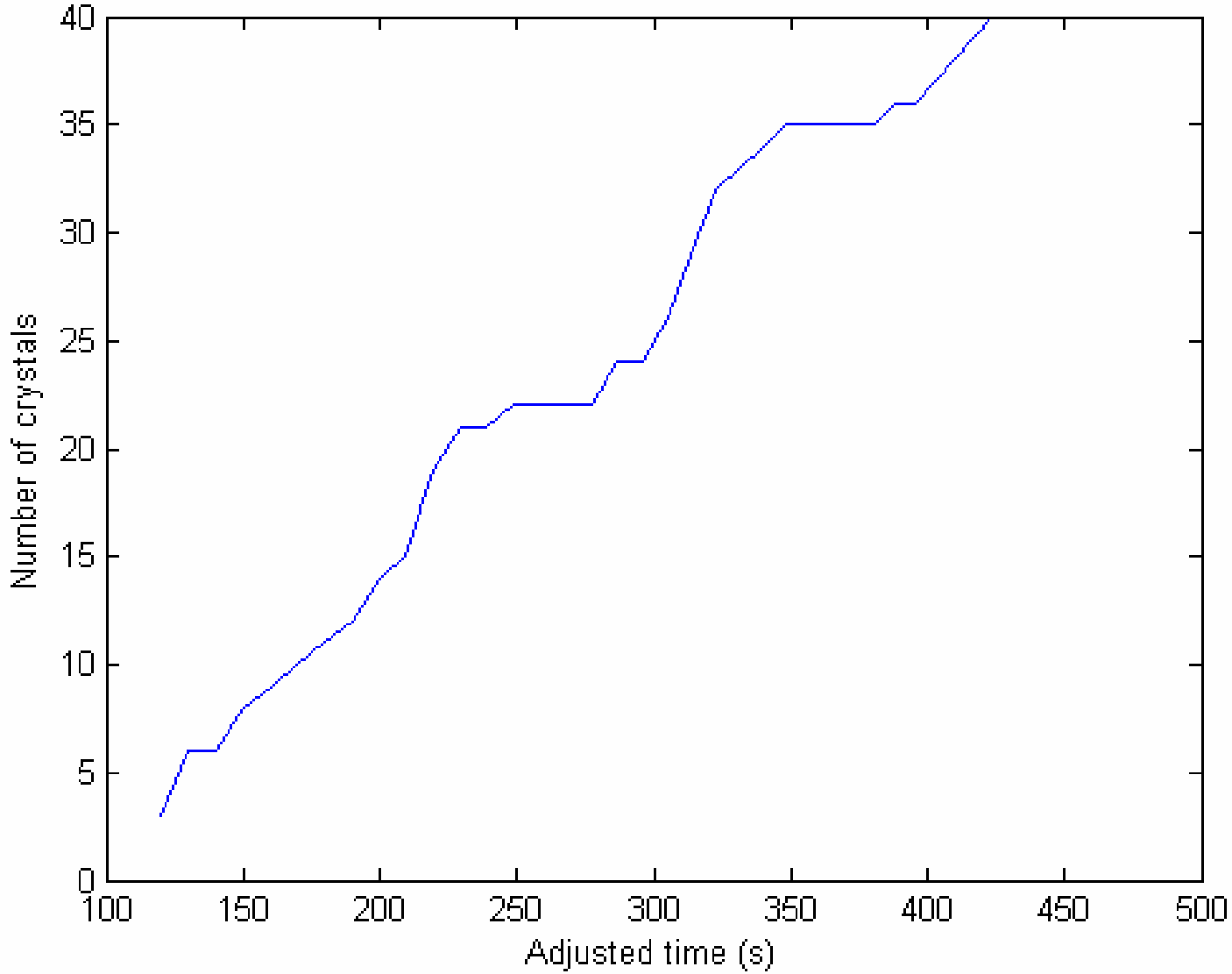


Nucleation rate

- Nucleation can only occur from a liquid.
- So should see a decrease in nucleation rate as the liquid fraction (X) decreases.
- We are really interested in nucleation rate per unit liquid volume (not total sample volume).
- Can adjust the time axis to reflect this as follows:

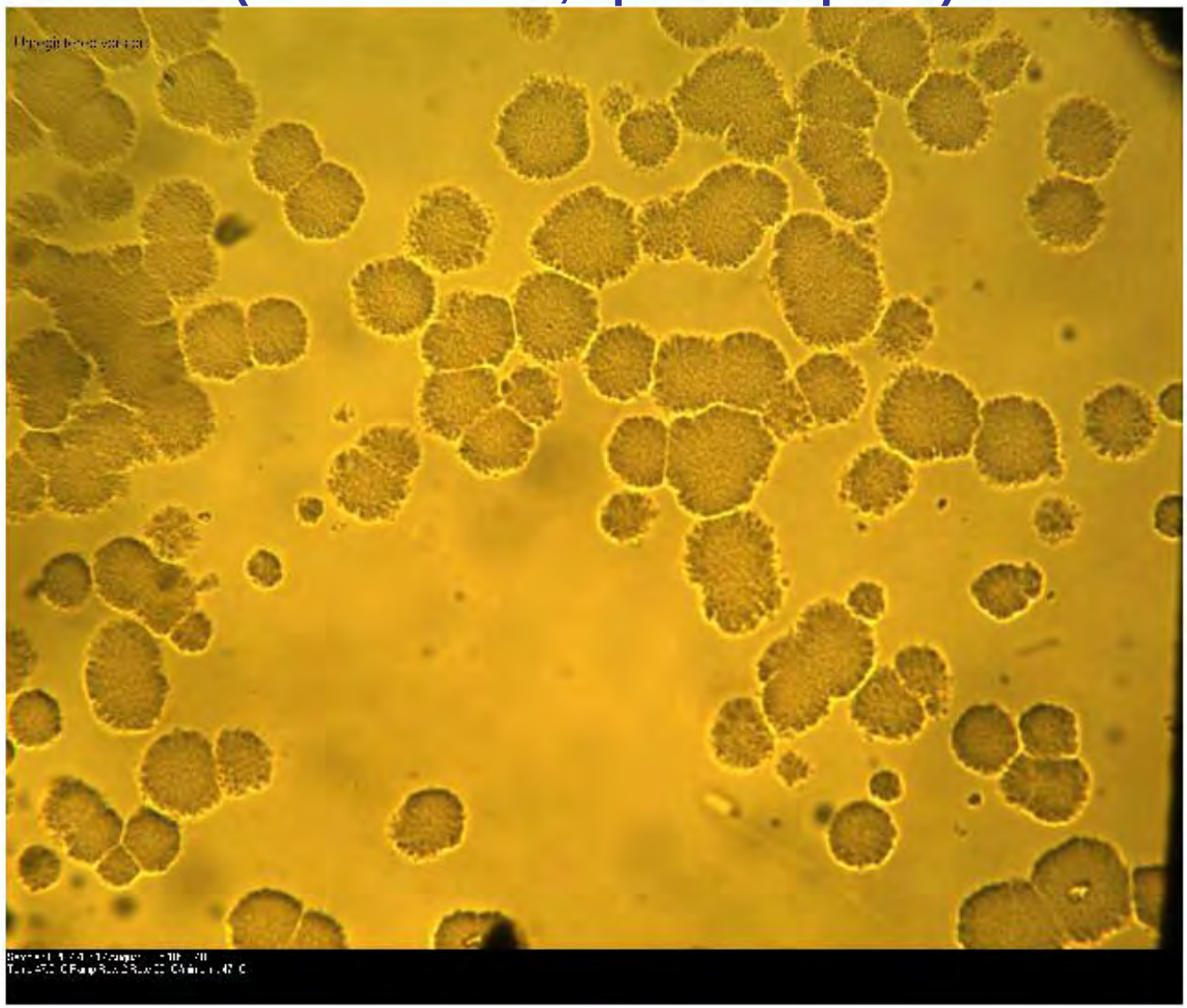
$$t_{adj} = \int_0^t X \, dt$$

No. crystals vs adjusted time (PPP @ 49°C)

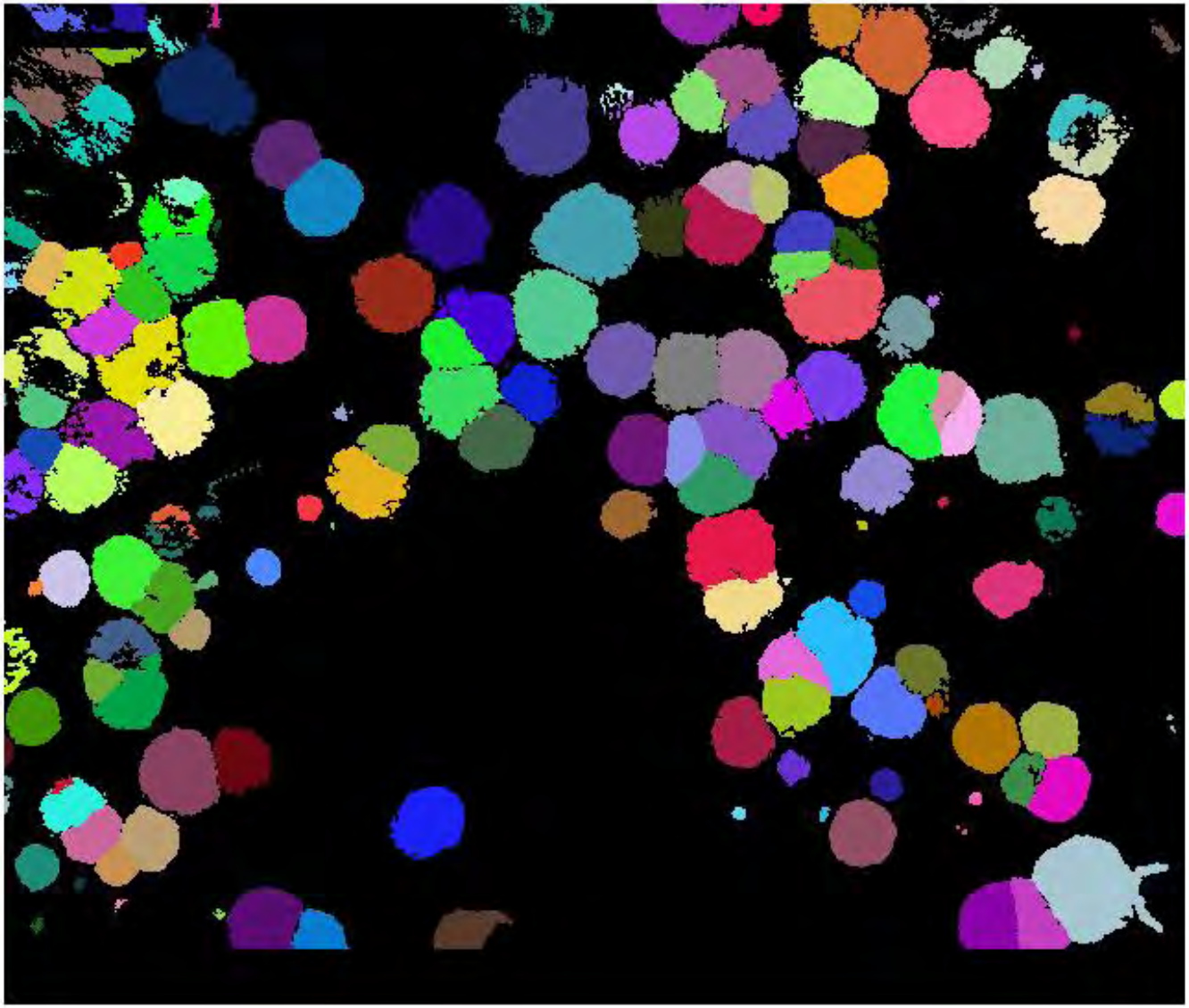


Tripalmitin (PPP) at 47°C

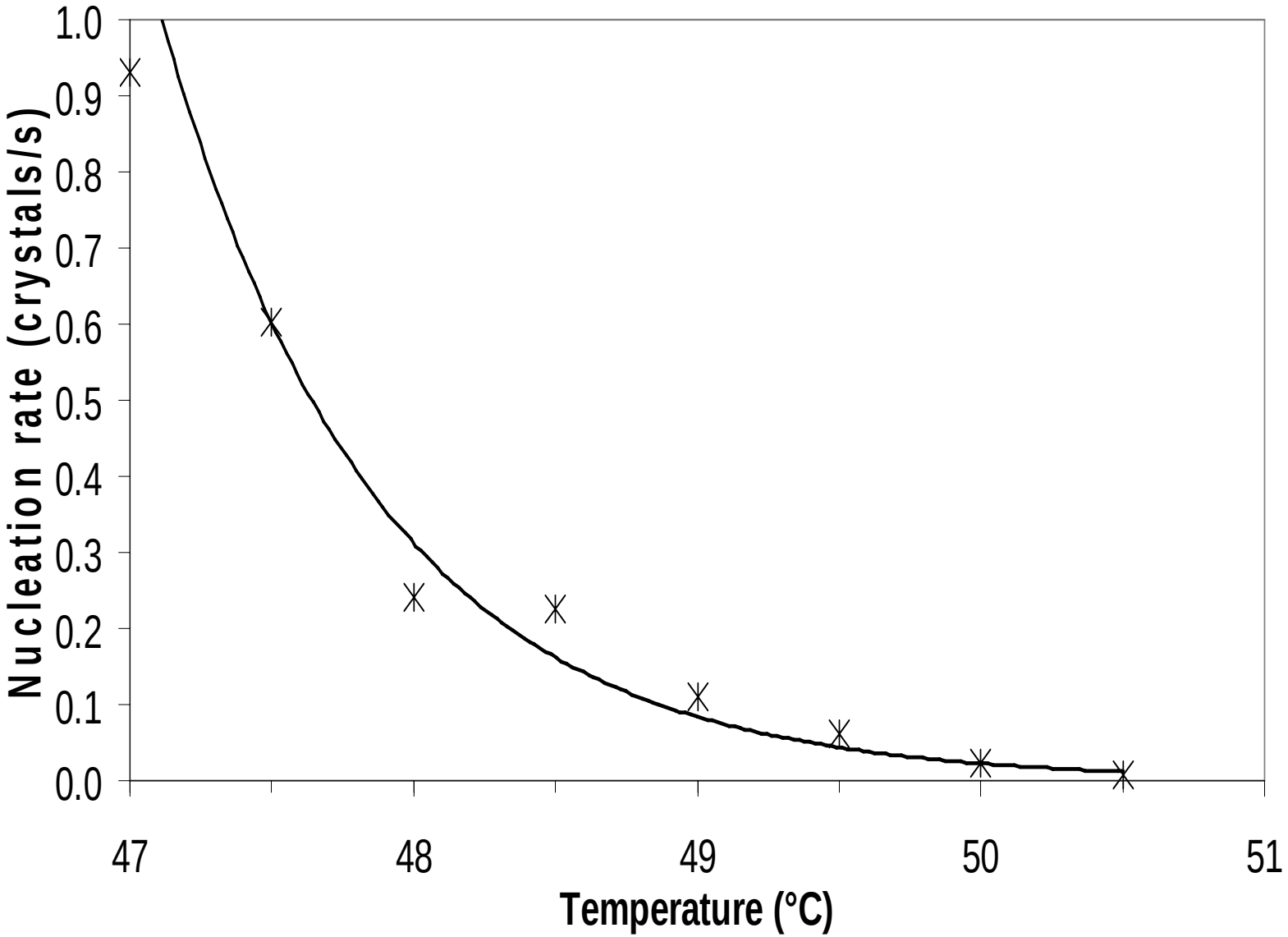
(1.75 x 1.5 mm; speeded up x25)



Tripalmitin (PPP) at 47°C

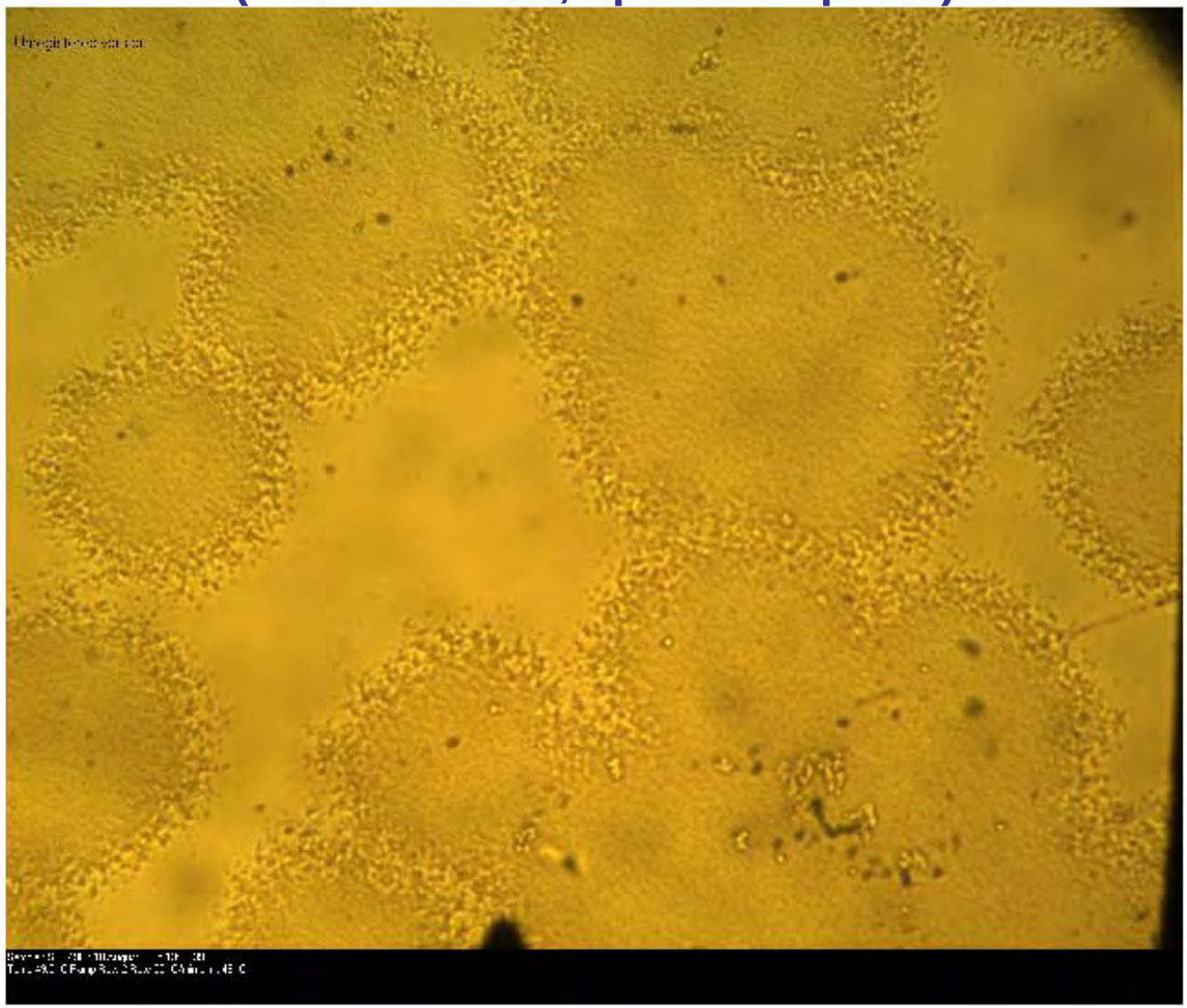


Nucleation rate vs temperature (PPP)

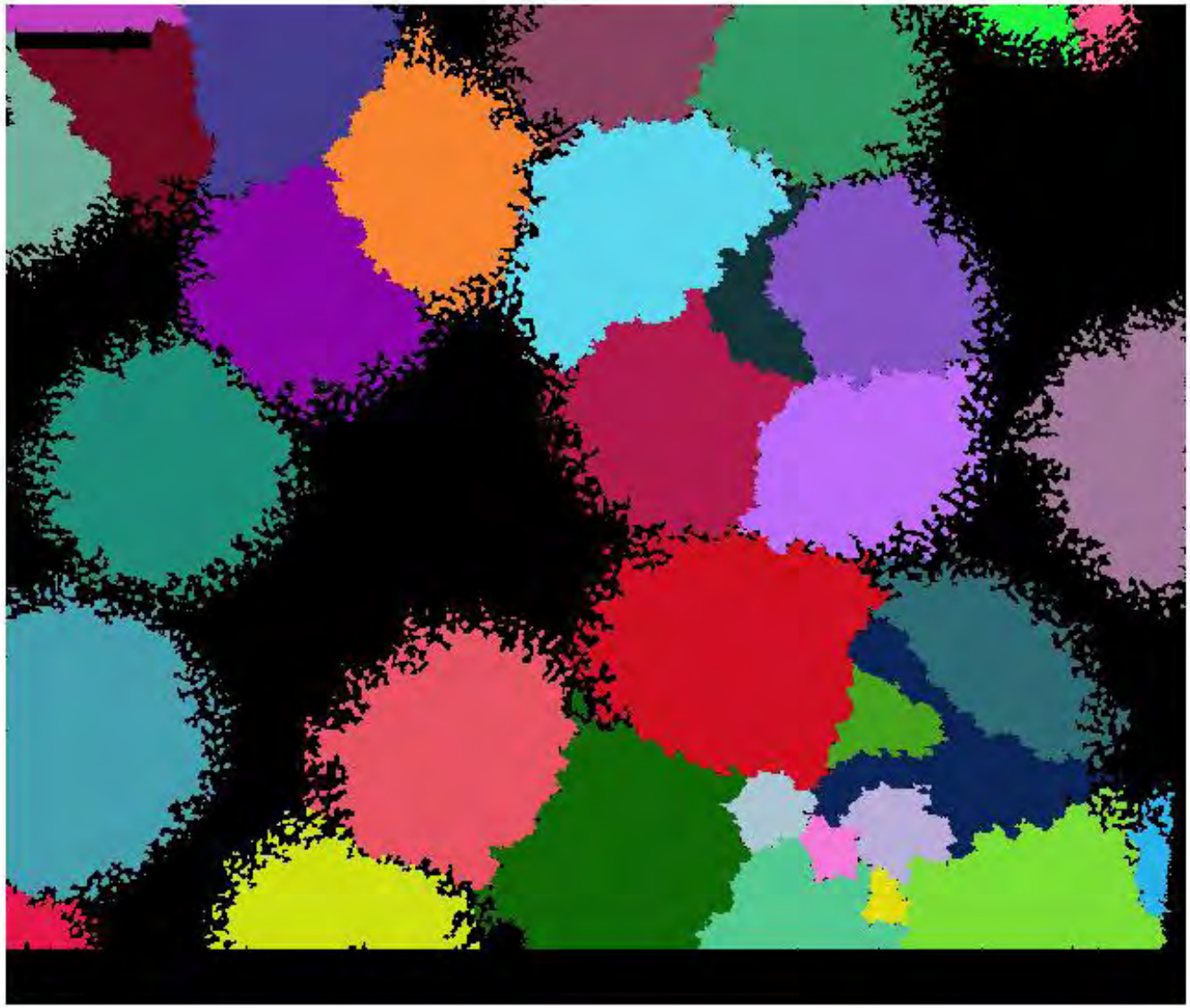


Mixture PPP/SSS 70:30 @ 49°C

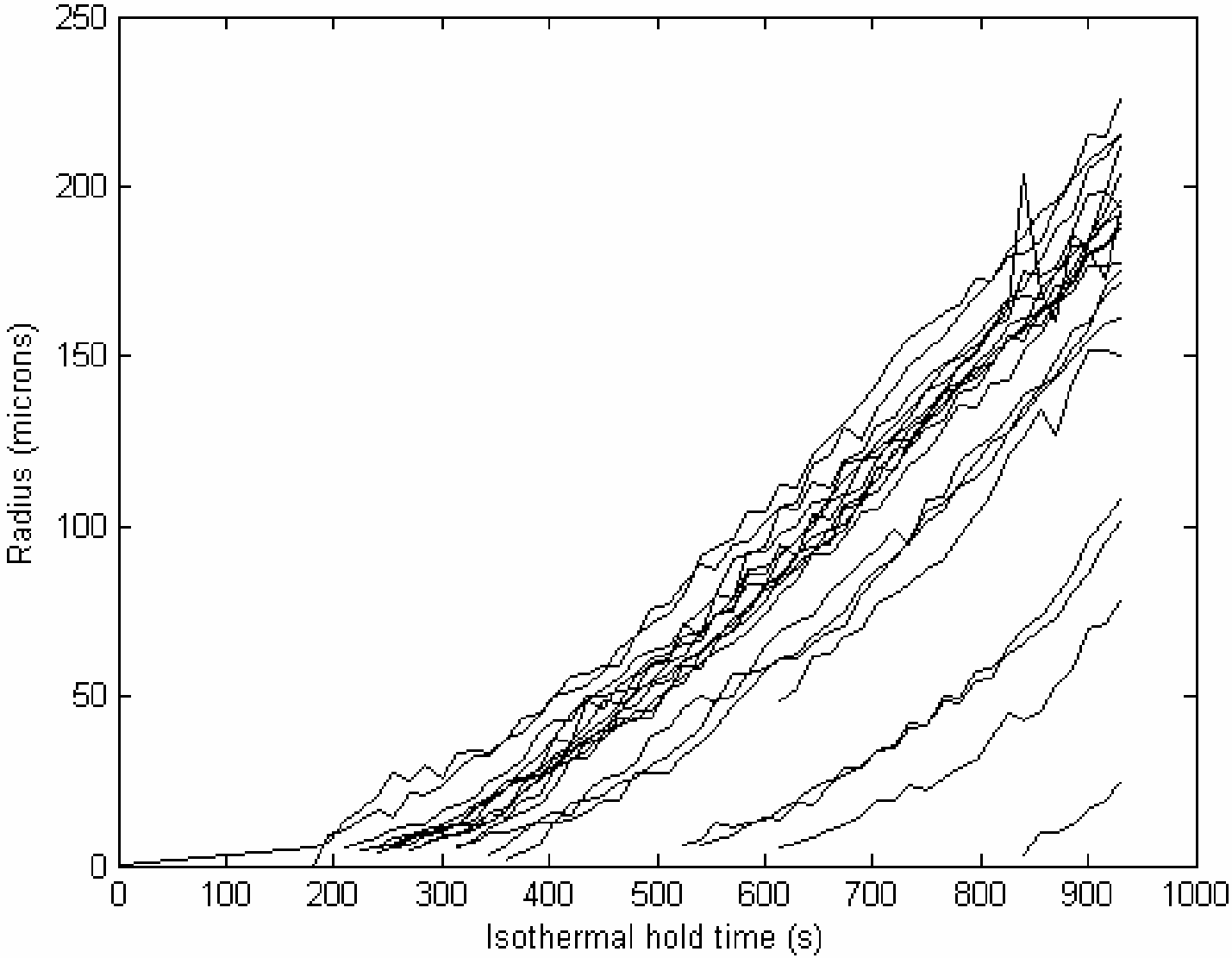
(1.75 x 1.5 mm; speeded up x75)



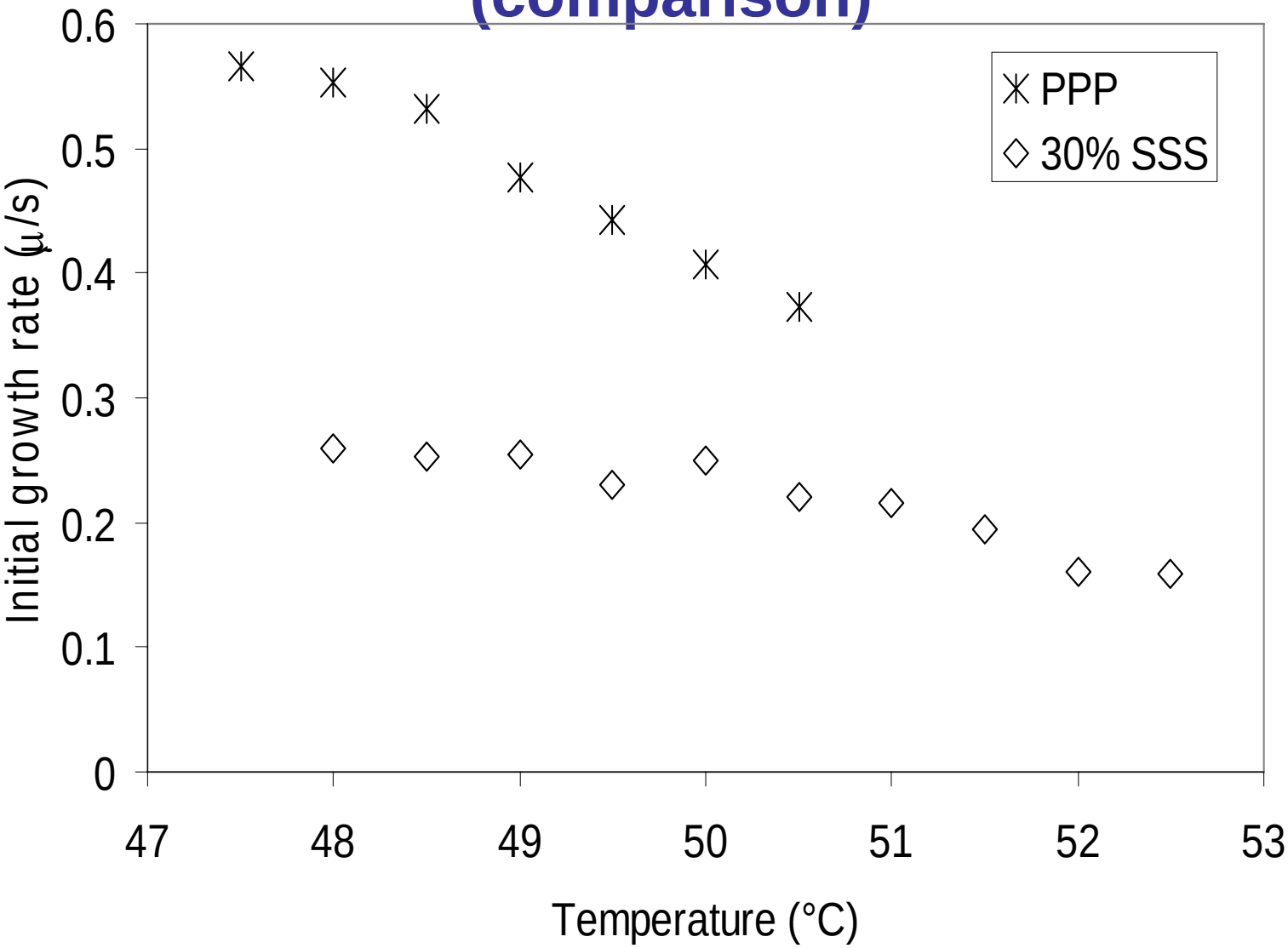
Mixture PPP/SSS 70:30 @ 49°C



Radius vs time (PPP/SSS 70:30 @ 49°C)



Initial growth rate vs temperature (comparison)



Summary – Optical Microscopy/Image analysis

Pros

- Can follow individual crystals.
- Can measure growth rates and nucleation rates independently.
- Small sample size – can control temperature easily.
- Small sample size – can study expensive TAGs.

Cons

- Sample dimensions constrained to thin wafer.
- Static system – no shear.
- Image analysis is computationally intensive and time-consuming.

Acknowledgement

We wish to thank the Biotechnology and Biological Sciences Research Council (BBSRC) for funding this work.

Thank you for listening