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RELATIVE FLOW POROSITY IN PAPER

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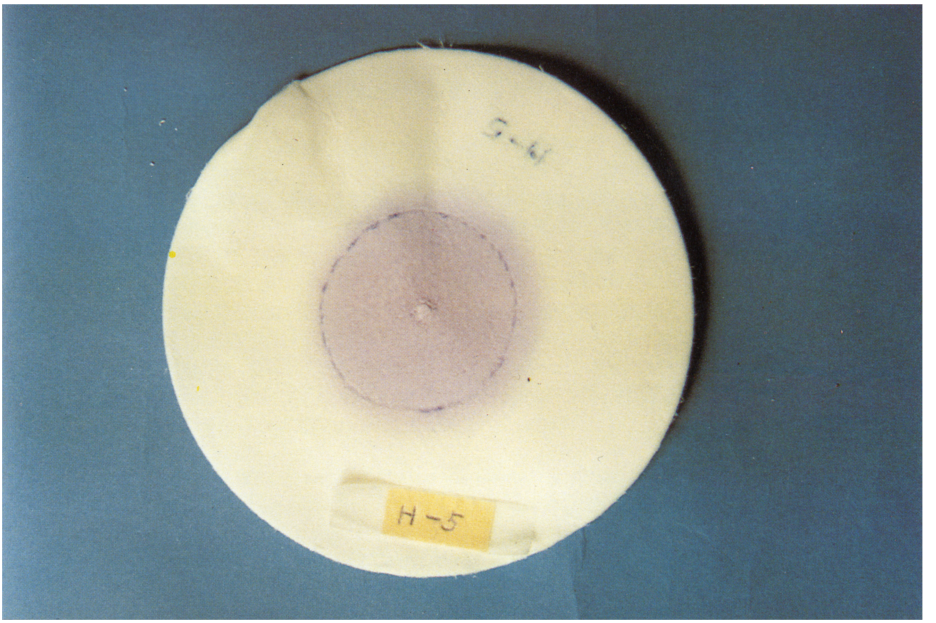

Figure 9. Blotter paper sample photographed after in-plane dye injection.

RELATIVE FLOW POROSITY OF PAPER

J D Lindsay

Dr F El Hosseiny, Weyerhaeuser Paper Co, USA
This is a very good piece of work. I congratulate you on it. My question is - in your work you have forced the liquid by pressure and you concluded that there is a negligible amount of dead space what would happen if you just put a drop of liquid and let the liquid go through - would you still have the same conclusion?

J Lindsay
I doubt it. In the problem of imbibition of a liquid into a dry medium when capillary forces are playing a role, you get several complications occurring. One of these is the presence of air space interfering with the entrance of the fluid and there is this relative permeability concept when there is two-phase flow occurring.
You will get pockets of air in some case trapped that interfere with the flow of the fluid. We have tried to avoid situations where capillary and two-phase flow effects will be important so I am not well prepared to answer that.

F El Hosseiny
The reason I am saying that is that there are situations where there is no forced liquid through, for example, starch gluing of medium to liner etc. so I guess we will just have to differentiate between the two cases.

J Lindsay

There is always this trade off between capillary imbibition and pressure drive and B Lyne talked about this earlier this morning,. We did look at some cases when we initially started off with some dry air saturated sheets of paper and then using low pressures still pressure drove the fluid in and got results very similar relative porosities in 90's and 80's and sometime 70's. That table I skipped over (Table 4 Page 962) for dry blotter paper was an example of that. From what I have seen when there is pressure drive the interference of air is relatively minor but I don't have those numbers for pure capillary drive.

Dr K Ebeling, Kymmene Corp, Finland

Congratulations for a very good piece of work and experimental technique you have developed. Have you done any work with sheets containing mechanical pulp or lots of fillers? If so what are the results or what would be your expectations concerning the volume occupied by the so-called dead end pores?

J Lindsay

I will take that as a suggestion because we deliberately avoided fillers so far in this work and we realise there is a need to approach that. We have done some work with newsprint but I do not have that data available. We have really focused on kraft pulps.

Dr L Wagberg, SCA Research AB, Sweden

Have you tried any liquids with different electrolyte concentrations to see the possible effect of surface swelling of the fibres or swelling at all.

J Lindsay

That is a very good suggestion but we have not. In most cases the sheets were initially saturated with distilled water. We are now using a different technique to measure salt concentration electrically and we had some problems with that and we are still working - It is a very good suggestion I would be interested in that myself.

Dr W Hewertson, CSIRO, Australia

I would like to follow up on that first question regarding low pressure. Paper chromatography has long been used by Chemists to separate materials particularly dyes of a polar nature. It may well be that you could refine your technique by using two different but similar dyes with quite different rates of movement to help you to get much more sophisticated in your methodology.

J Lindsay

That is a very good suggestion. We have done that. We have used two different dyes. I mentioned dye specific artefacts as one of the problems that have to be examined in this case. One of the first dyes we used was one that tended to absorb onto paper and that creates some real complications. The dye we have primarily used is Versatint Purple II which is a fugitive dye, non absorbing. We have also used a dextran blue with a molecular weight on cellulose of ca.$2x10^6$. We have also used a mixture of those two because we expected significantly different diffusion parameters for the dextran and the lower molecular weight Versatint Purple. We used a mixture of those two dyes to try to see if we could get a separation effect and in the experiment as we ran it, the axial diffusion component for both at the velocities we use is not significant enough to cause a separation or visible difference between those two. When we stop

the process, take the sheet out and let it sit for an hour or two, you do get separation. Even with Versatint Purple II there is a couple of different molecular weights in there, or species, a yellowish or purplish. When bulk flow ceases and as longitudinal molecular diffusion becomes important, you do see slow separation. In the work we are doing, we take advantage of molecular diffusion to help decrease axial dispersion - we have enough velocity so that the molecular diffusion in the R direction of the sheet is not really significant. So we do not see the separation effect.

B Wahlstrom, Borje Wahlstrom Inc

Very interesting. I have one question. You use for swollen fibre volume data based on the Kozeny-Carman equation which is a flow related measurement. Would you thus not expect to get the results you got?

J Lindsay

The question is really – is it based on a circular type of reasoning. That is a good point. The specific volumes we sometimes measure are based on z direction flow and our measurements are then made in plane flow where the shape of the pores presented to the flow are different. I hate to mention that because it raises the issue of anisotropic relative porosity and I do not want to touch that now.