ELECTRIC-KINETICAL MEASURES ON OFFSET PRINTING PLATES

NORBERT KUEHN
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First experimental measurements with potassium-chloride-solutions and fountain solutions at printing-plates-materials and inks principal confirmed the existance of electro-chemical double layers.
The composition of the electro-chemical double layers is causes by the adsorption from OH-Ions out of the aqueous fountain solution. That observed time-dependence of the zeta-potential at the interface isopropanol-solution/copying layer point out unequivocally to phenomenas of diffusion and swelling toward, which together with the mechanical influences during the printing process could lead to the untimely destruction of the copying layers.
With knowledge of the isoelectric point of the hydrophilic areas of offset-printing plates is possible an exact vote between the isoelectric point and the pH-value of the fountain solution to the decreasing of phenomena of "inking", partly causes by uncontrolled adsorption inversely loaded particles on the hydrophilic areas of the offset-printing plates.

Introduction

This article reports on electro-kinetic investigations on materials for the offset-printing to contribute to further clearing up of interfacial chemical phenomenas of the offset-printing .

Few fundamental comments about electric-kinetical appearances

The chapter of scientific analysis of electric-kinetical appearances started already in 1807 with Reuss' observation /1/ that the laying of a voltage on a diaphragma filled with liquid leads to a streaming of this liquid.
If solids are in contact with aqueous solutions, as reguested in offset-printing, then is an other distribution at the limit of phase of the electric charge-carriers as in the inside of solid respectively of the liquid phase. The enrichment of charge-carriers at the phase-limit leads to the formation an electrical potential-difference contrary the inside of this phase.

This potential-difference is predicted to Freundlich /2/ as zeta-potential. The calculation of the zeta-potential follows to equation 1/3/:

$$\zeta = \frac{4\pi \ \eta \ \chi \ E}{\varepsilon \ \Delta P}$$

With,

ε = relative dielectric constant
η = dynamical viscosity of the liquid
ΔP = hydro-static pressure-difference
E = streaming potential
χ = specific electrical conductivity of the liquid

Water has concerning viscosity and dielectric constant values similar to aqueous electrolytical solutions. Therefore one can transform this equotion:

$$\zeta = 1,1 \times 10 \ \left(\frac{E}{\Delta P} \right) \ \chi$$

Electric-kinetical measurements and offset-printing

The first orientating experimental investigations confirmed basically the existence of electric-chemical double layers between aqueous solution and copying layers respectively inks (figure 1).
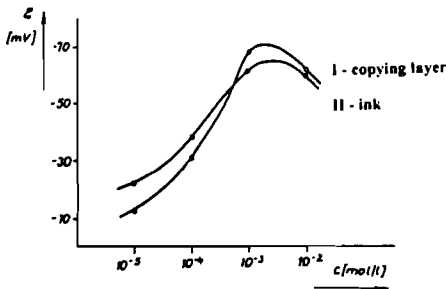

figure 1: zeta-potentials at inks in KCl-solutions

We see that the values of both of the zeta-potentials are very similar. One can expect that, because of both materials, the copying layer and the ink are hydrophobic materials. The structure of the electric-chemical double layers is caused by the same principle.

For the zeta-potentials of copying layers and inks in potassium-chloride-solutions the typical parable-alike curve-course for hydrophobic polymeric materials was found. This materials form the electro-chemical double layer by adsorption from OH-ions out of the equeous solution (figure 2).
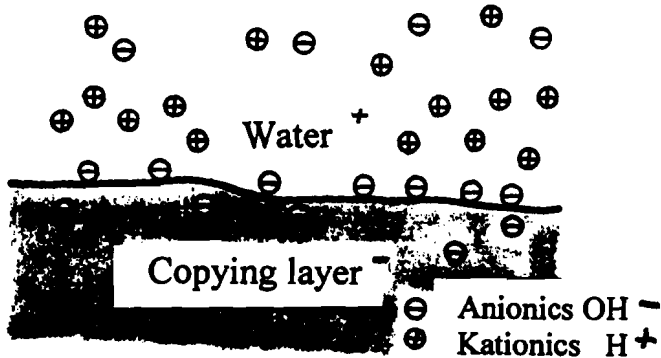

figure 2: negative charging of the copying layer by adsorption from OH-ions out of the fountain solution

Figure 2 demonstrates the principle of the structure of the electric-chemical double layers. This principle is valid for all hydrophobic polymeric materials which are in contact with aqueous solutions.

Swelling of the copying layer by fountain solutions

Extensive investigations of the reduction of the zeta-potentials in dependence of time on materials, which tend to swell where accomplished by Kanamaru /3/. This increasing of the water-admission the zeta-potential will be reduced considerably. This knowledge permits the derivation also to the technology of the offset-printing , on the correlation between fountain solution and copying layer. With the aim to find out possible negative influence of fountains solution on copying layer electric-kinetical measurements of the interfaces isopropanol-solutions / copying layer
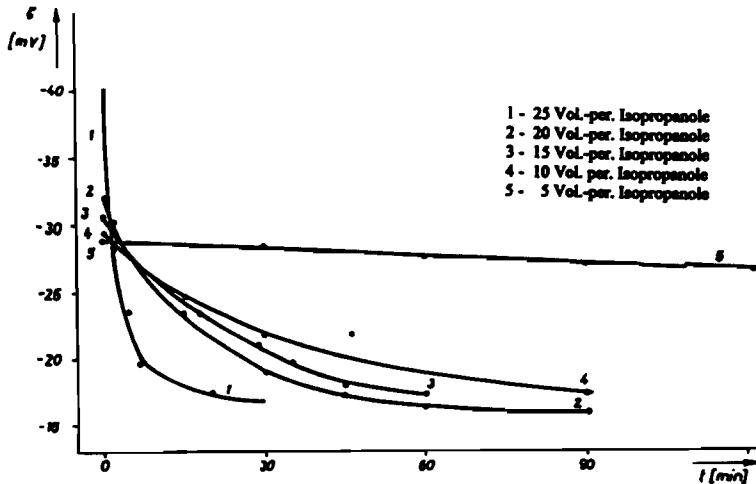
figure 3: zeta-potential/time-curve at copying layer in aqueous isopropanol-solutions

One can see that in dependence on the cnncentration of the isopropanole soutions in contact with the copying layer exist different curve-courses. These curves demonstrate the swelling of copying layers in attendance of isopropanole solutions. A concentration of 25 vol.-per cent leads to a quick swelling of the copying layer.

To Kanamaru /4/ and Jacobasch /5/ one can lead away, that copying layers are swelling by definite substances of the fountain solutions in the areas near the surface. This swelling together with the mechanical influences during the printing process leads to the untimely destruction of the copying layer.
For the daily practice in the offset-offices following demands evolve:
1. Accurate observance of technological prescriptions to the set concentration of fountain solutions, what in the praxis has not garanteed.
2. Take of substances out of the fountain solution, that could cause a swelling of the copying layer.
3. Worranty of an optimal balance between fountain solution and copying layer. On figure 3 one can recognize well that the copying layer principally tends to the swelling in attendance of isopropanol. Higher concentrations have a significant effect on the swelling of the copying layer especially at a high quantity of copies and therefore there is a negative effect on the mechanical stability. More as 15 volume-percent isopropanol in the fountain solution should principally not be used. These results also stand in consensus with practical experiences in printing offices.

Isoelectric point of the nonprinting areas of offset-printing plates

At the surface of many metall-oxides are formed OH-groups during contact with water. These OH-groups can react amphotericly. An amphoteric dissociation, that means one part of the hydroxyl-groups reacts sourly and the other part reacts alkalicly, one can transfer to the development of a model of the electro-chemical double-layer at the interface aluminum-oxide/aqueous solution /6/.
All amphoteric materials and in order to also out of aluminum-oxide consisting nonprinting areas of the offset-printing plate, have an isoelectric point. That is measurable by the means of streaming potential experimentally. The isoelectric point is characterized by the same number of negative and positive charges. About the correlation between influence of charge and adsorption there are investigation of Weigl and Baumeister /7/.
This correlation is of meaning for an aimed balance between the pH-value of the fountain solution and for the hydrophilic areas of the offset-printing plate.
How is well-known, the pH-value of the fountain solution plays an important role in the printing of a high quantity of copies. According to experiences should be the pH-value of the fountain solution between 4,0 and 6,5 during the printing pro-cess with aluminum printing plates.
Underneath pH-value 4,0 is often to observe the so-called "naked-running" of the ink-cylinders, that means the ink-acceptance is disturbed by too much acidity in the fountain solution. The upper limit of the pH-value is marked, especially at very hard water, through the "inking" of the nonprinting areas of the offset-plate.
For this upper limit of the pH-value there is until now no scientific explanation, that permits a sensible balance between pH-value of the fountain solution and the non-printing areas. All former explanations on the inking by the variation of the pH-value are in connection with pH-values in the alkaline ranking of the fountain solution and become lead back mainly on reactions, which manage the formation and deposit of lime-soaps on the offset-plate /8/.
The "inking" , often already in the range pH 6,0 until 7,0, was until now not explicable.
An explanation for it is possible by the determination of the isoelectric point of the nonprinting areas with electro-kinetic measuremts. The determination of the zeta-potentials in dependence of the pH-value of the solution at the hydrophilic areas shows an isoelectric point near pH 6,0. That is how the practical experiences are proofed. (figure 4).
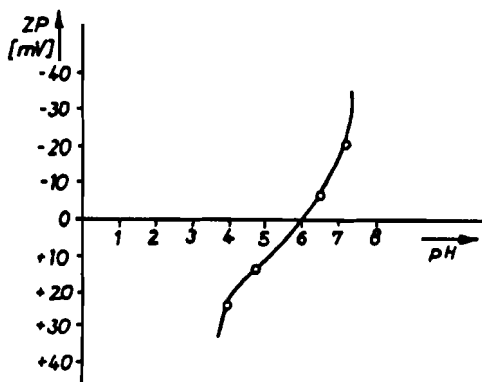
figure 4: zeta-potential / pH-curve at the hydrophilic areas of offset-printing plates

For the first look one can see that the curve cuts the horizontal axis. A general chemical law is that the electric-chemical double layer underneath of the pH-value of the isoelectric point is loaded positively and upper of the pH-value of the isoelectric point is loaded negatively.

Out of that following technological conclusions can be derived:
1. The zeta-potential has underneath the isoelectric point
   a positive accedental at the interface hydrophilic area / aqueous solution.
   Near pH 6,0 a charge-reversion takes place, that means above pH 6,0 the
   interface is charged negativly.
2. Inks and paper contain a high number of cationic components. A charge-
   reversion above the isoelectric point has a preferential adsorption of
   these positive loaded particles by Coulomb-interactions at the aluminum-
   oxide-surface to the consequence.
Due to these relatively strong interactions one cannot eliminate the "inking",
caused by the adsorbtion of ink-particles on microscopicly little sites, no
longer by simple methods, for instance by increasing the amount of the fountain
solution or the spattering on the printing-plate with acidity-solution. In many cases
is necessery a change of the printing-plates, which spent additional working time
and causes losses at material.
At too low buffer-capacity of the fountain solution could follow a charge-reversion
during the printing process.
Often the printers give uncontroled quantities of phosphorus-acidity or other
aggressive substances into the fountain solution, which often destroy the surface of
the printing plates.
Cause for the "inking" is often a too low or altogether no buffer-capacity in the

required pH-zone 4,0 until 6,0 or eventuelly a high pH-value above 7,0 (strong alkaline) of papers, which has a quick consumption of the buffer-capacity to the consequence. Especially then, if many substances
of the surface of this alkaline papers come into the fountain solution. At high-qualitative papers is to observe a strong trend to more alkaline portions in the last years.Hence the demand follows to the use of a strong buffer for the pH-value-zone between 4,0 until 6,0, to prevent a charge-reversion.
The isoelectric point at the surface of the nonprinting areas must be under pH 7,0, because at the surface of the printing plates produced to an exakt technology exist more sour as alkaline groups. In accordance with the treatment of the aluminum in sulphur-sour bathes one could expect also this result.

Due to the knowledge of the isoelectric point of the hydrophilic areas, a scientifically fundamented correlation between the pH-value of the isoelectric point and the pH-value of the fountain solution can be exüplained for the first time. The conscious application of this correlation can be used for further scientific stabilization of the offset printing process.

Dr. Norbert Kuehn
Max - Lingner - Str. 12
04347 Leipzig
Phone: 03 41 / 2 33 00 30
Fax: 03 42 92 / 7 36 16

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