Quality Assessment of Binder Pitches

M.H. Wagner*), I. Letizia**), S. Giannini**),
H. Tillmanns*), G. Wilhelmi*)

*) SIGRI ELEKTROGRAPHIT GMBH, D-8901 Meitingen, W-Germany
**) ELETTROCARBONIUM S.p.A., I-05036 Narni/Terni, Italy

Introduction

The aim of this long-term project is to define the binder pitch properties relevant for carbon and graphite electrode production. In the first part of this investigation, carbon and graphite rods of diameter 20 mm were produced under standard conditions by use of 17 different binder pitches. Cross correlations of pitch properties and correlations of pitch to artifact properties are presented.

Experimental

9 petroleum pitches and 8 coal tar pitches having a wide range of properties (see table 1) were included into this investigation. The filler coke, a premium needle coke with maximum grain size of 0.7 mm, was mixed for 45 minutes at 160 °C with an optimum quantity of binder pitch. The optimum amount of binder was judged from the extrusion pressure. The extruded stock was baked to 850 °C and graphitized at 2800 °C. For both carbonaceous (amorphous) and graphitized grades, 6 samples were taken and bulk density, el. resistivity (with grain), and flexural strength (with grain) were determined.

Results

Cross Correlations of Pitch Properties

Pitches of coal tar and petroleum origin show an overlap in their respective range of data (table 1) for softening point (KS), temperature of equiviscosity (TEV), Alcan coke (AC), vacuum distillate at 4.8 torr (VD), and content of β-resins. A gap exists between the two populations for density (DP), atomic C/H ratio, and content of quinoline insolubles (α-resins). It should be kept in mind that this gap is bridged by coal tar impregnation pitches, which have not been included into this investigation, however.

Treating both populations as one ensemble, the following strong interrelations between pitch properties can be detected (r = correlation coefficient):

$TEV=59.7 + 1.11 \cdot KS$, $r = 0.93$ (1)
$AC = 67.3 - 0.73 \cdot VD$, $r = 0.84$ (2) (fig.1)
$DP = 0.939 + 0.209 \cdot C/H$, $r = 0.99$ (3)

$DP = 1.251 \cdot \alpha^{0.021}$, $r = 0.98$ (4)

$C/H = 1.48 \cdot \alpha^{0.080}$, $r = 0.99$ (5) (fig.2)

Especially the properties density, atomic C/H ratio, and content of α-resins are strongly interrelated.

Correlation of pitch/artifact properties

The binder requirement (R) for optimum plasticity is correlated to the content of α-resins of the pitch:

$R = 28.7 + 0.22 \cdot \alpha$, $r = 0.91$ (6)

The artifact bulk densities in the amorphous and graphitized state, ADA and ADG, show the strongest correlation with the atomic C/H ratio:

$ADA = 1.21 + 0.166 \cdot C/H$, $r = 0.94$ (7)
$ADG = 1.23 + 0.158 \cdot C/H$, $r = 0.95$ (8)

Table 1: Properties of Binder Pitches

Pitch Property		Abbrev.	Range of Data for Petroleum Pitches	Range of Data for Coal Tar Pitches
Softening Point (KS)	°C	KS	81 - 108	70 - 94
Temperature of Equal Viscosity	°C	TEV	136.6-188.4	125.1-163.1
Density of Pitch	g/cm³	DP	1.210-1.249	1.288-1.343
Atomic C/H Ratio	-	C/H	1.30 -1.44	1.71 -1.86
Alcan Coke	%	AC	43.4 -55.6	49.7 -62.2
Vacuum Distillate	%	VD	11.6 -30.8	12.0 -22.8
Quinoline Insolubles (α- Resins)	%	α	0.2 - 1.1	5.5 - 16.5
β-Resins	%	β	5.3 -28.0	16.1 - 23.5

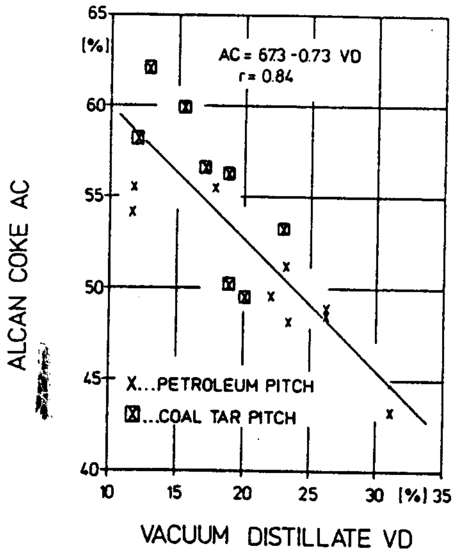

Fig. 1

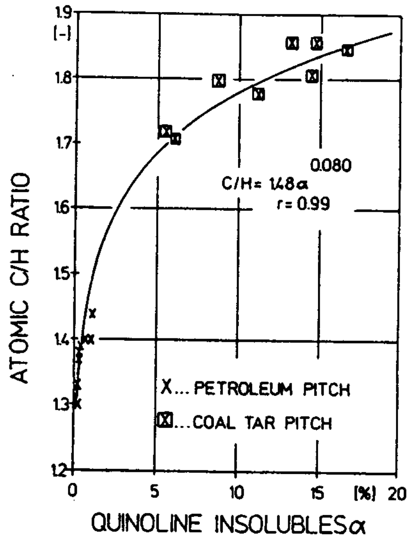

Fig. 2

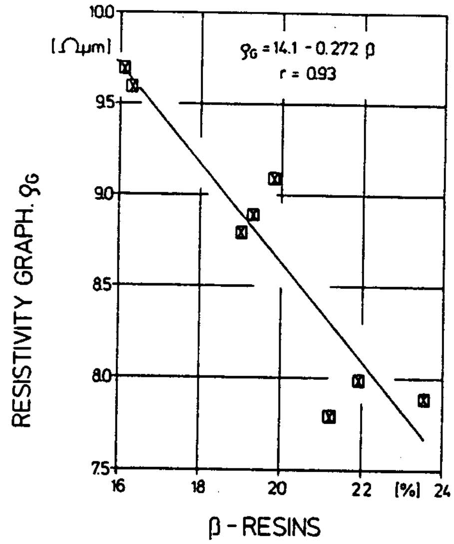

Fig. 3

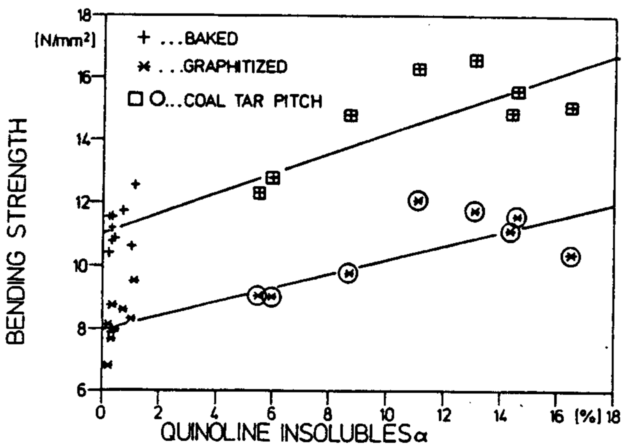

Fig. 4

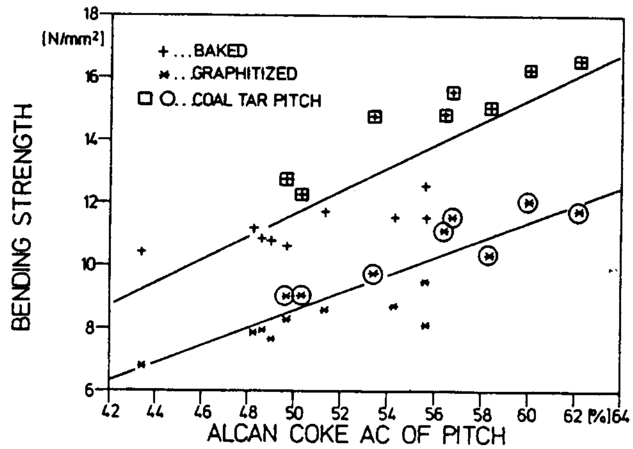

Fig. 5

For the electrical resistivity measured both on amorphous and graphitized samples, no clear correlation to the pitch properties could be found. However, for coal tar pitches only, a strong dependence exists for the el. resistivity of the graphitized samples, ρ_G, on the content of ß-resins (fig. 3):

$$\rho_G = 14.1 - 0.272 \cdot ß, \; r = 0.93 \quad (9)$$

The correlation of flexural strength with content of α-resins and Alcan coke is shown in fig. 4 to 5 respectively.

It is obvious from fig. 4 that maximum strength is achieved by coal tar pitches with 10 to 14 % of quinoline insolubles. The best linear correlation for flexural strength in amorphous (baked) and graphitized state, SA and SG, was found by combining the influences of Alcan coke AC and atomic C/H ratio:

$$SA = -6.63+0.192 \cdot AC+5.85 \cdot C/H, r=0.97 \quad (10)$$
$$SG = -5.60+0.176 \cdot AC+3.47 \cdot C/H, r=0.96 \quad (11)$$

Conclusions

Binder pitches should have a high coke yield and a high atomic C/H ratio for optimum artifact bulk density and strength. A high content of ß-resins is important for low electrical resistivity of graphite artifacts. These results are in basic correspondence with experience on large diameter electrodes.