THERMAL NON-COKING COAL PREPARATION BY TRIBOELECTRIC DRY PROCESS

LICENTIATE THESIS

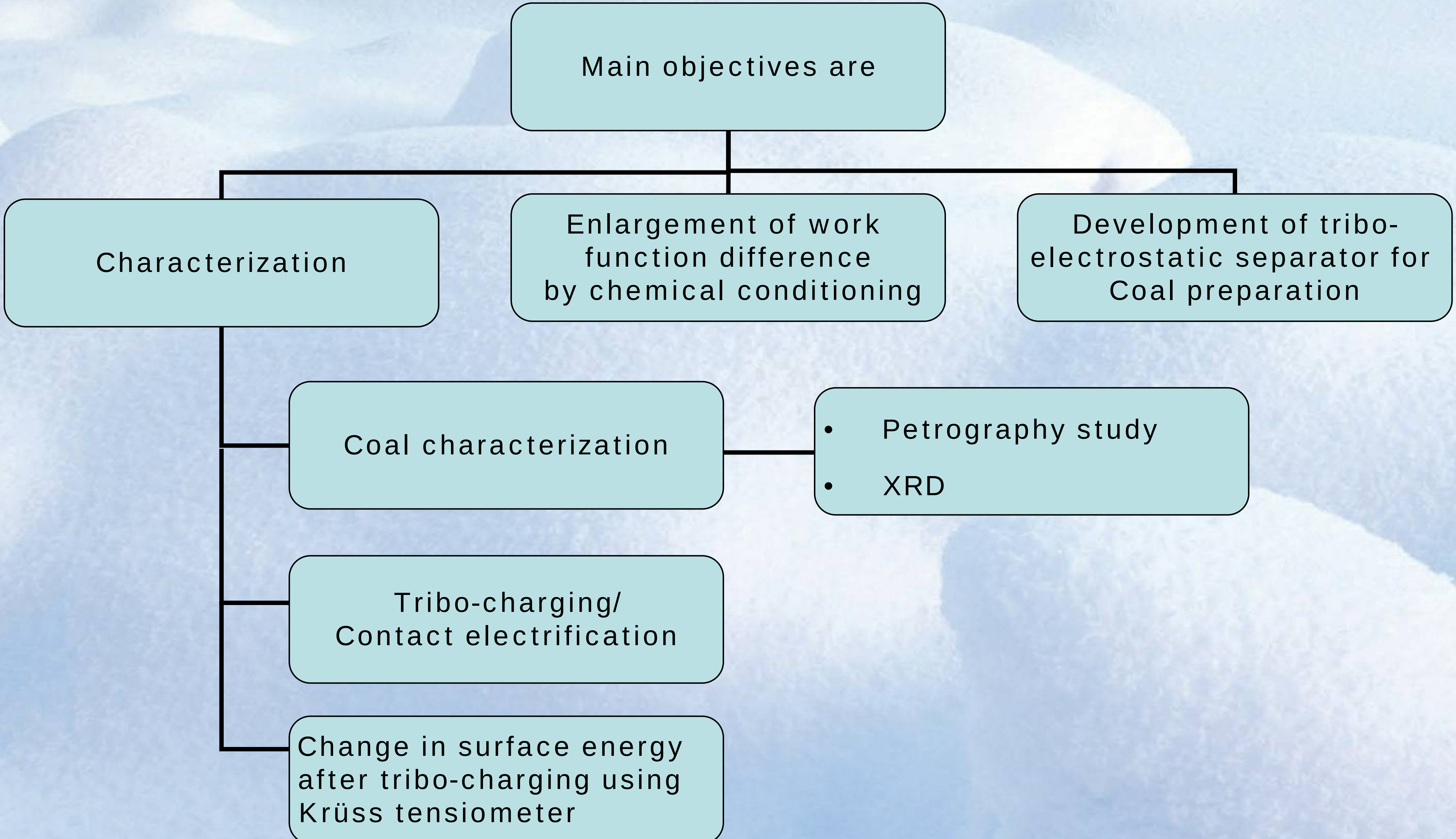
Ranjan K. Dwari

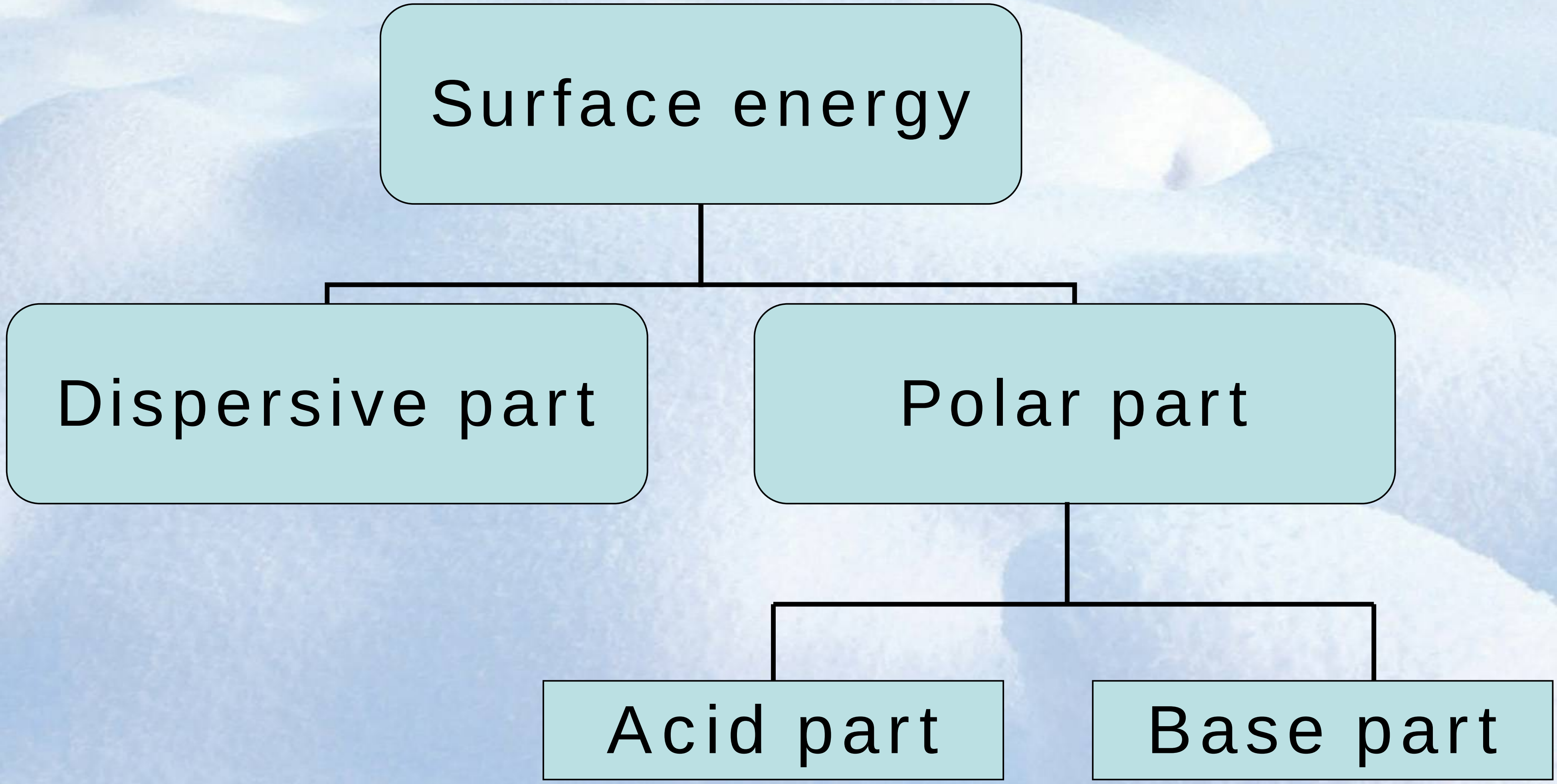
Supervisor: Prof. K. Hanumantha Rao

Division of Mineral Processing
Department of Chemical Engineering and Geosciences

The northernmost University of Technology in Scandinavia
Top-class Research and Education

SWEDISH INTERNATIONAL DEVELOPMENT COOPERATION AGENCY


Main objectives are
Characterization
Enlargement of work function difference by chemical conditioning
Development of tribo-electrostatic separator for Coal preparation
Coal characterization
• Petrography study
• XRD
Tribo-charging/ Contact electrification
Change in surface energy after tribo-charging using Krüss tensiometer


Surface energy
Dispersive part
Polar part
Acid part
Base part

Theories to measure solid surface energy

- **Fowkes theory**

$$\left(\gamma_s^D \gamma_l^D\right)^{1/2} + \left(\gamma_s^P \gamma_l^P\right)^{1/2} = \frac{\gamma_l\left(1+\cos\theta\right)}{2}$$

- **Owens/Wendt approach.**

$$\frac{\gamma_l\left(\cos\theta+1\right)}{2\left(\gamma_l^D\right)^{1/2}} = \left(\gamma_s^P\right)^{1/2} \frac{\left(\gamma_l^P\right)^{1/2}}{\left(\gamma_l^D\right)^{1/2}} + \left(\gamma_s^D\right)^{1/2}$$

- **van Oss acid-base approach.**

$$(1+\cos\theta)\gamma_l = 2\left[\left(\gamma_s^{LW}\gamma_l^{LW}\right)^{1/2} + \left(\gamma_s^{+}\gamma_l^{-}\right)^{1/2} + (\gamma_l^{+}\gamma_s^{-})^{1/2}\right]$$

- **Equation of state approach.**

$$\gamma_s - \frac{\left[\left(\gamma_s\right)^{1/2} - \left(\gamma_l\right)^{1/2}\right]^2}{1-0.015\left(\gamma_s\gamma_l\right)^{1/2}} = \gamma_l \cos\theta_l$$

Surface energy of solid by Krüss tensiometer

The Washburn (1921) method was used to determine the liquid contact angle on powders. Essentially, the Washburn equation defines the liquid flow through a capillary and it is given as:

$$\frac{m^2}{t} = \frac{c.\rho^2.\gamma_L.\cos\theta}{\eta}$$

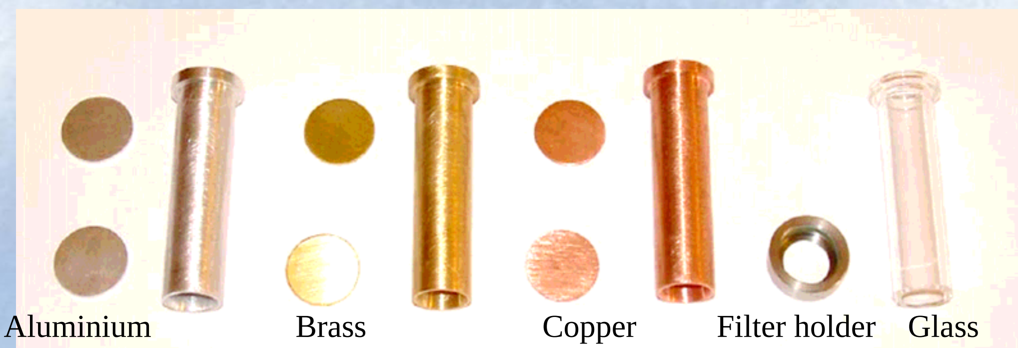


Fig. Sample holder made up of aluminium, brass, copper and glass

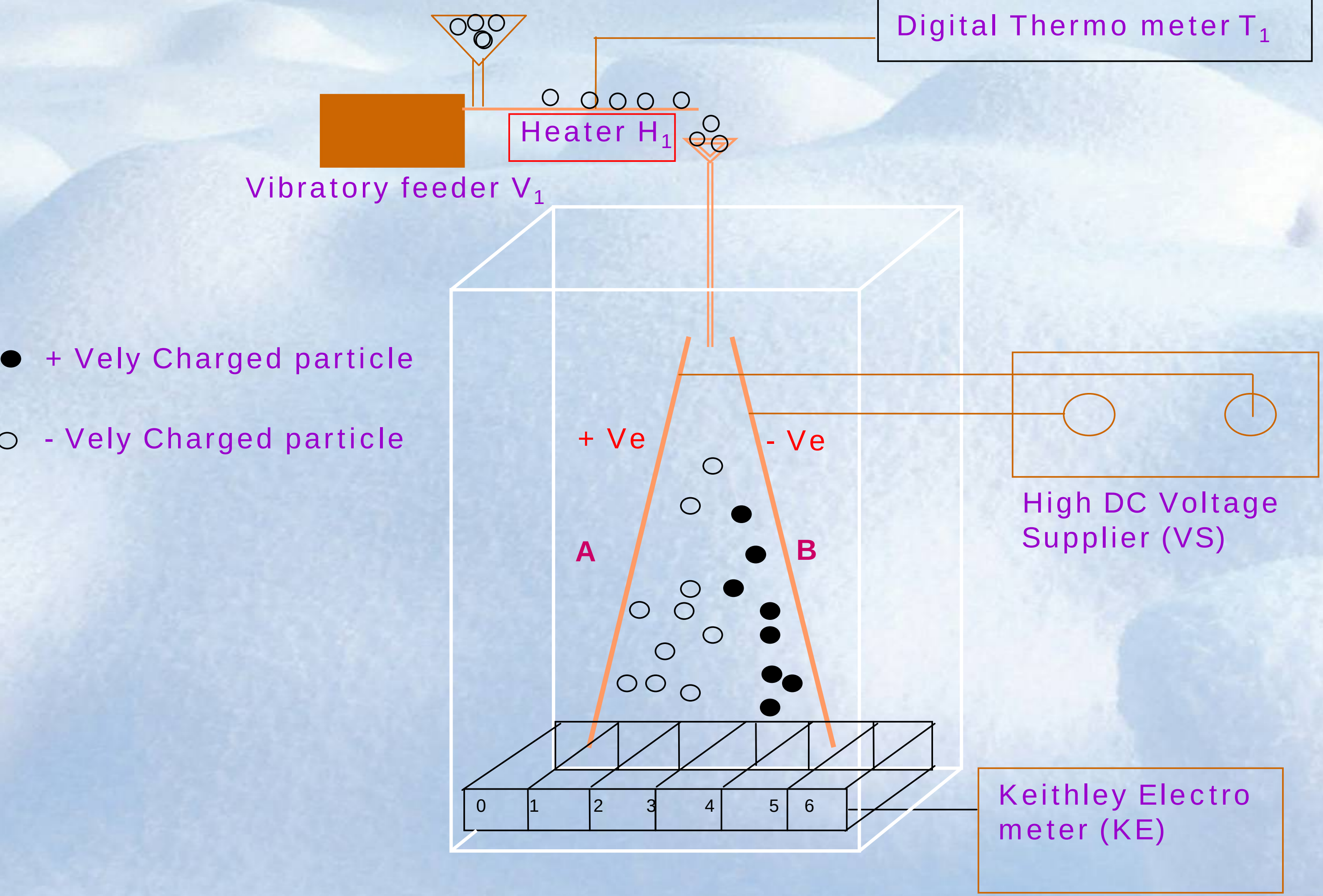


Fig. Schematic diagram of experimental set-up.

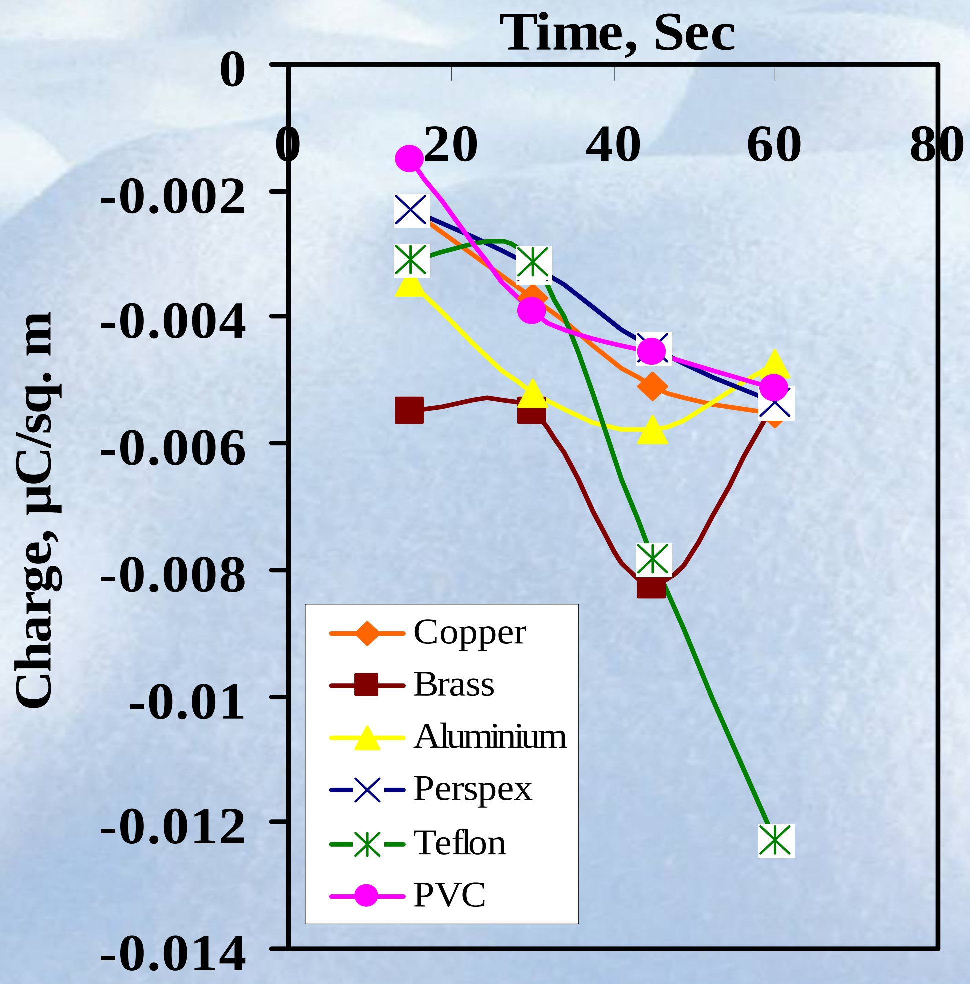


Fig. Influence of tribo-charging time on charge acquisition by quartz particles.

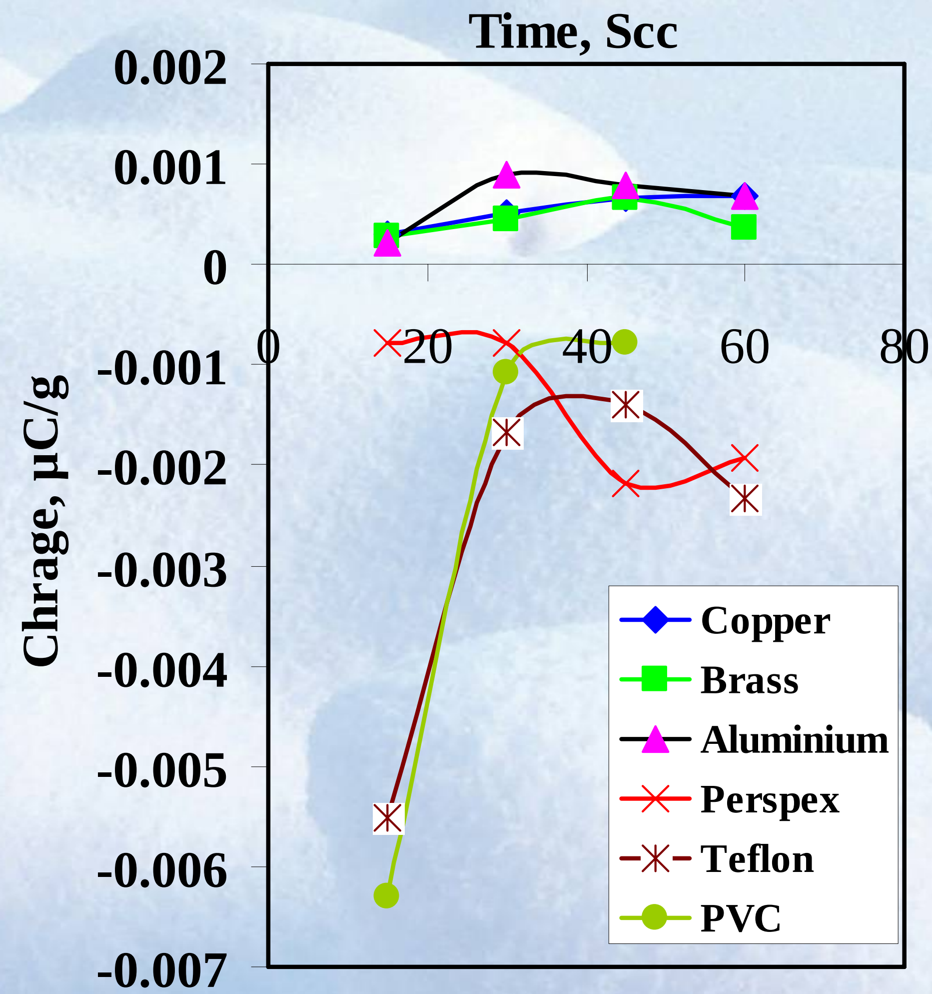


Fig. Influence of tribo-charging time on charge acquisition by carbon particles.

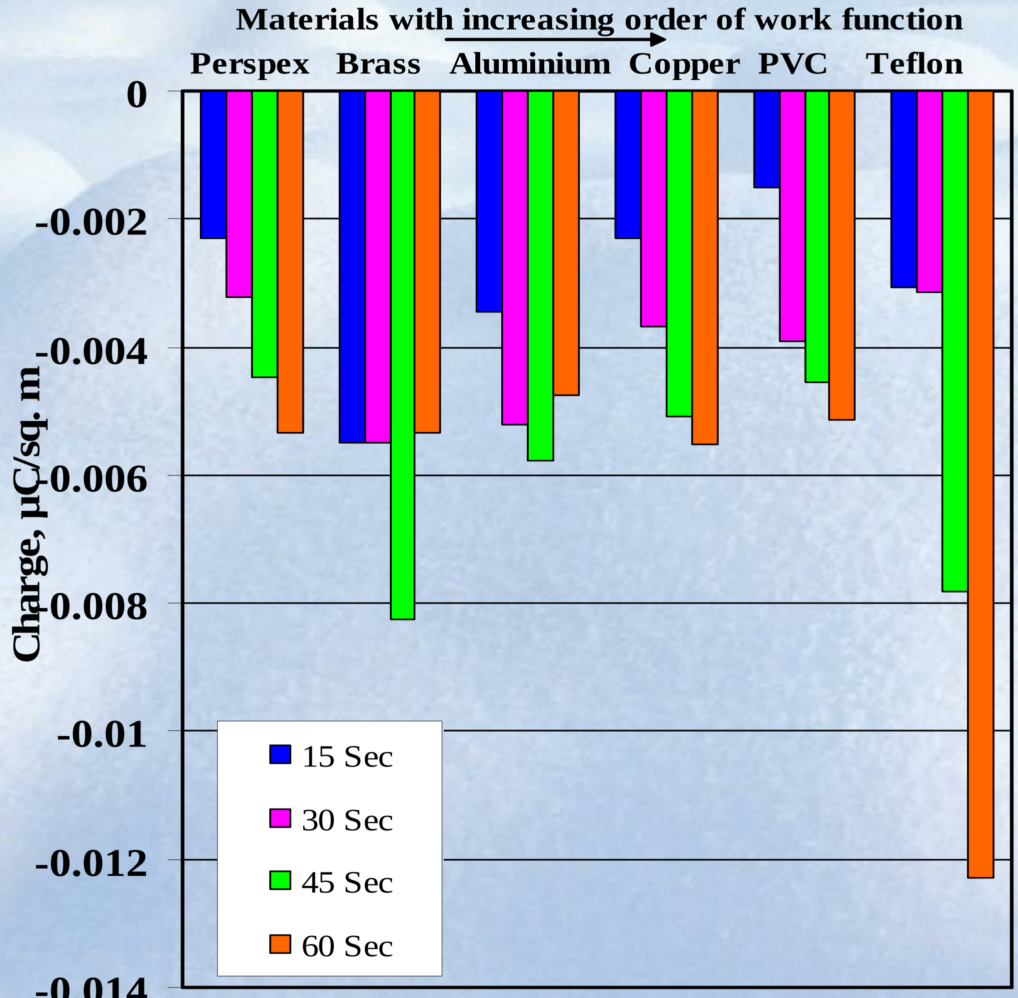


Fig. Influence of tribo-charging media and charging time on charge acquisition by quartz particles.

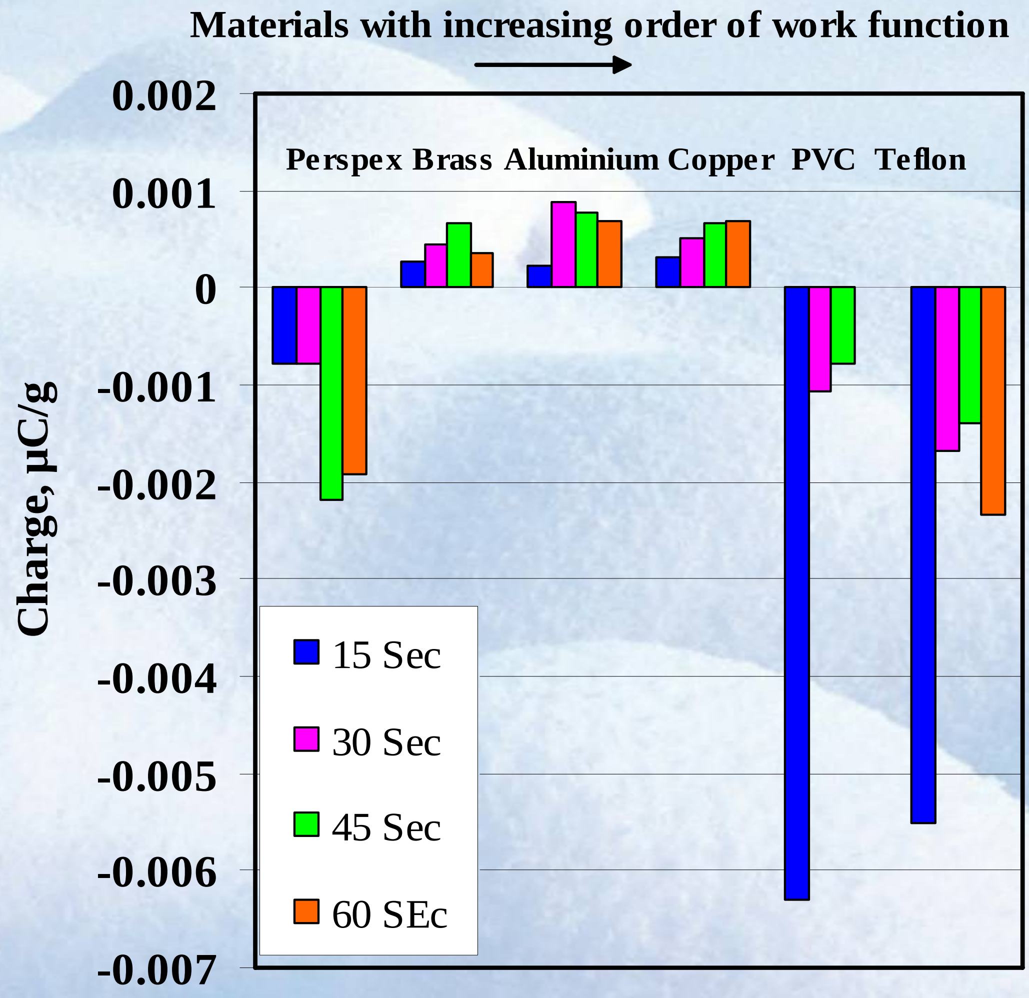


Fig. Influence of tribo-charging media and charging time on charge acquisition by carbon particles.

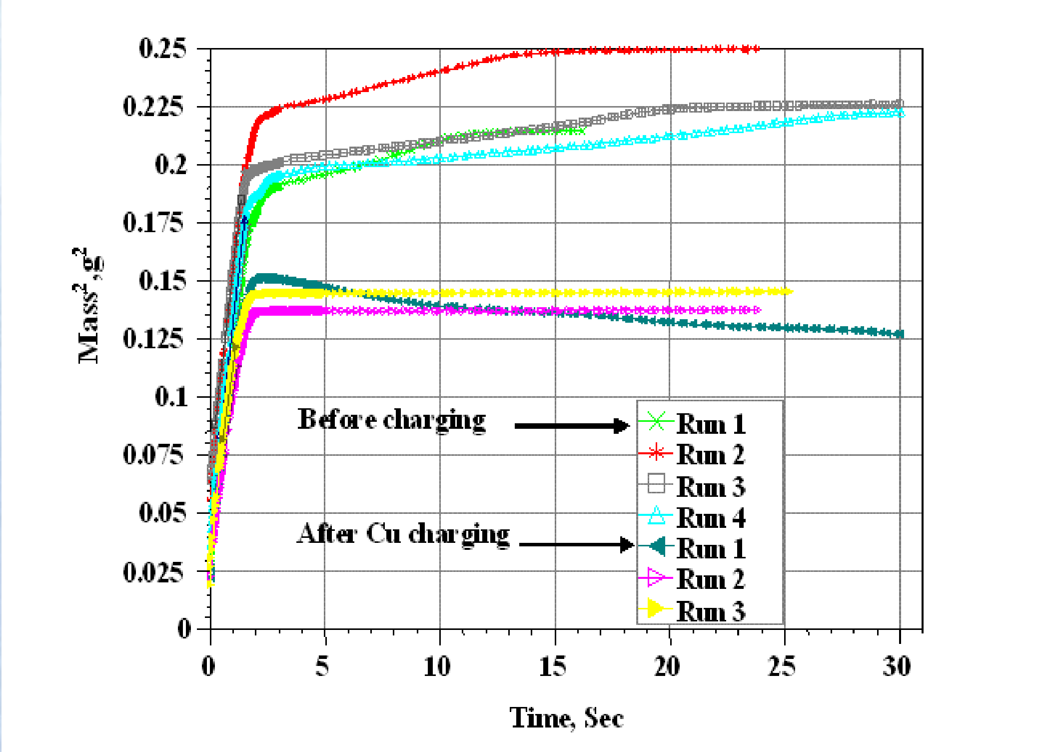


Fig. Effect of tribo-charging on sorption of n-hexane for Determining the capillary constant.

Table: Contact angle of test liquids on quartz powder at different sample holder materials.

Sample holder	Capillary constant, C, cm^5	Test liquids	Contact angle
Glass	3.0755E-5	n-hexane	0
		Water	38.24 ± 2.27
		Formamide	3.43 ± 1.18
		1-Bromonapthalene	51.87 ± 1.11
Copper	2.8015E-05	n-hexane	0
		Water	28.58 ± 0.49
		Formamide	5.18 ± 0.52
		1-Bromonaphthalene	44.54 ± 0.58
Aluminium	2.8229E-05	n-hexane	0
		Water	27.04 ± 1.48
		Formamide	4.52 ± 1.48
		1-Bromonaphthalene	43.6 ± 2.13
Brass	2.7793E-05	n-hexane	0
		Water	24.62 ± 1.19
		Formamide	4.57 ± 2.57
		1-Bromonaphthalene	37.88 ± 2.95

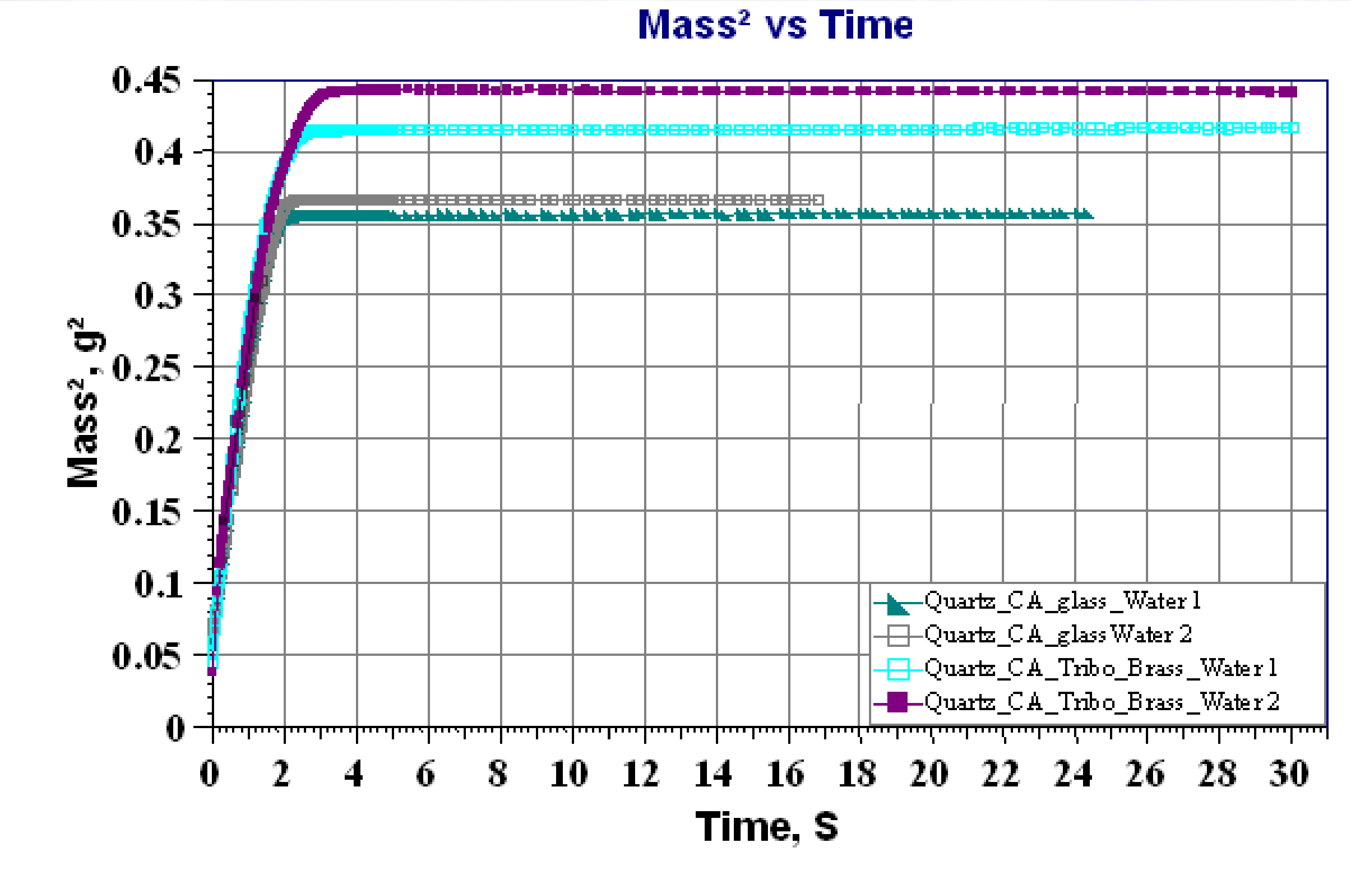


Fig. Effect of tribo-charging on sorption of water for determining the contact angle.

Table. Surface energy of quartz before and after tribo-charging using van-Oss acid-base approach using Water-Formamide-1-Bromonapthalene as test liquid.

Mineral	Surface free energy, mN/m	Disperse part, mN/m	Polar Part, mN/m	Acid part, mN/m	Base part, mN/m
Quartz before tribo-charging	56.46	28.90	27.56	6.78	28.03
Quartz tribo-charging with Copper	57.90	32.45	25.45	4.17	38.79
Quartz tribo-charging with Aluminium	58.11	32.88	25.23	3.97	40.12
Quartz tribo-charging with Brass	57.96	35.42	22.55	2.98	42.67

The magnitude of negative charge acquition by quartz with different metals is in the order of

copper < aluminium < brass

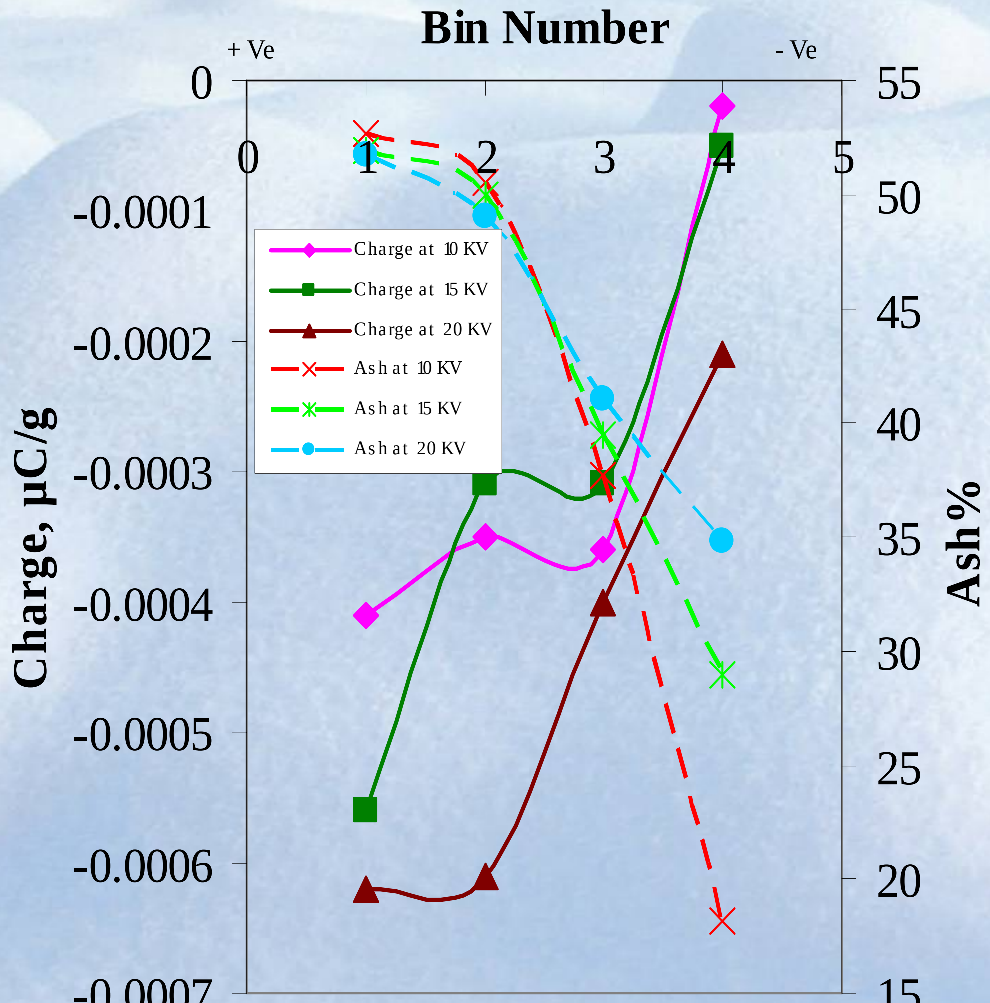


Fig. Effect of voltage on charge acquired and ash content of coal particles at different bins at 18ºC

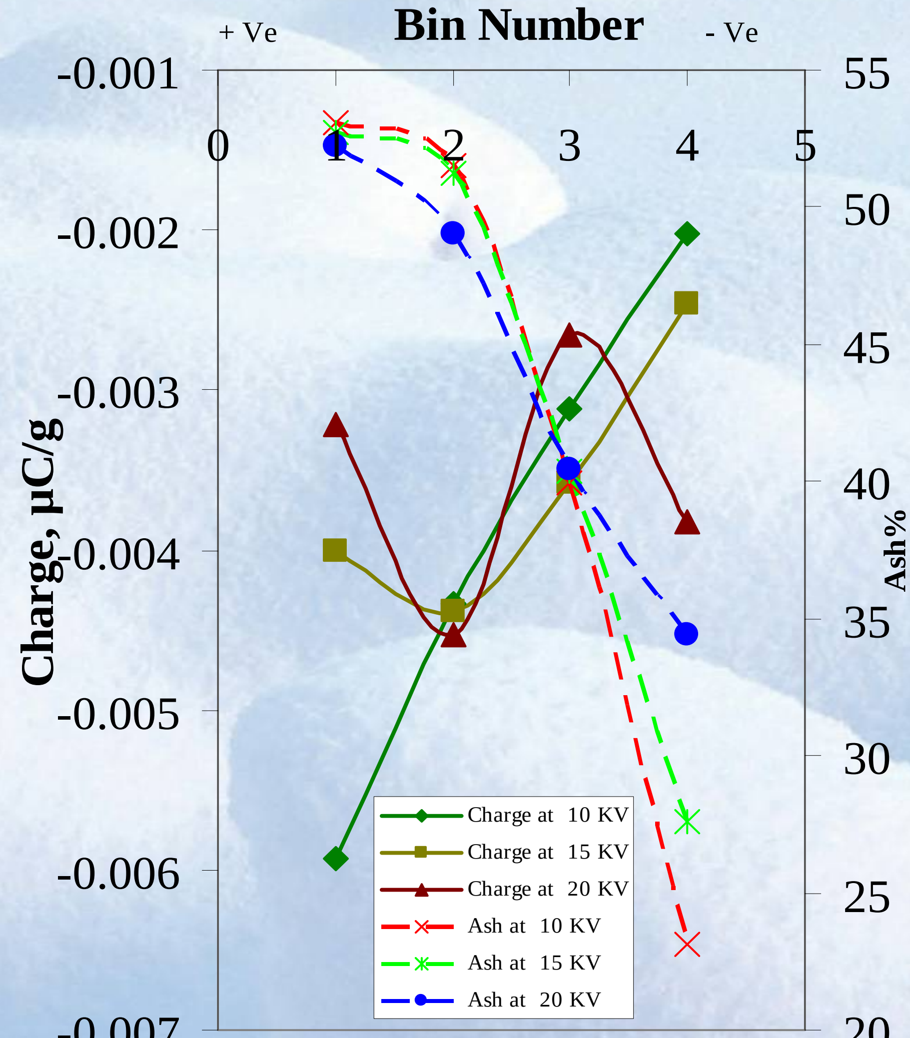


Fig. Effect of voltage on charge acquired and ash content of coal particles at different bins at 63ºC

Conclusion

The charge acquisition of quartz, kaolinite, illite and carbon after contact electrification with different tribocharging medium were studied.

The methodology adopted for determining the changes in surface energetic structure of solids, in terms of van Oss acid-base parameters, proved to be an appropriate technique.

Surface chemical conditioning can change the work function of particles to increase the differential charging for more efficient separation.

This technique can be extended to identify the optimum surface pre-treatment in tribo-electrostatic separation.

The results achieved illustrate an explicit correlation between charges generated by powders and the acid-base parameters determined through liquid contact angle data.

The present studies showed that it is possible to reduce the 45% ash coal to 18% ash clean coal and this technique might be extended to remove un-burned carbon from the fly ash and bio-mass fly ash.

Thank you
for your attention !!