ELECTROSEPARATION OF ADSORBENTS AFTER EDIBLE OIL BLEACHING: PROCESS EVALUATION AND CRITICAL PARAMETERS

FRANK PUDEL, MARCO ZENKER

PPM Pilot Pflanzenöltechnologie Magdeburg e. V.
Berliner Chaussee 66, D-39114 Magdeburg
Tel: +49 391/81 89 171; Fax: +49 391/81 89 299
www.ppm-madeburg.de

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Outline

1. Introduction: Electroseparation and its application in the edible oil refining
2. Description of problem and experimental setup
3. Results and discussion
4. Conclusions

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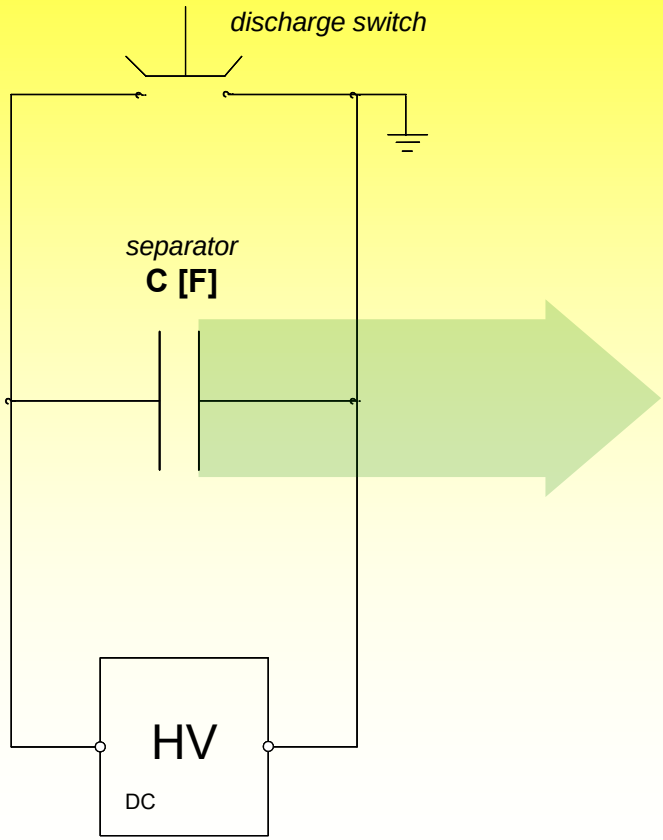
Introduction

ELECTROSTATIC SEPARATION

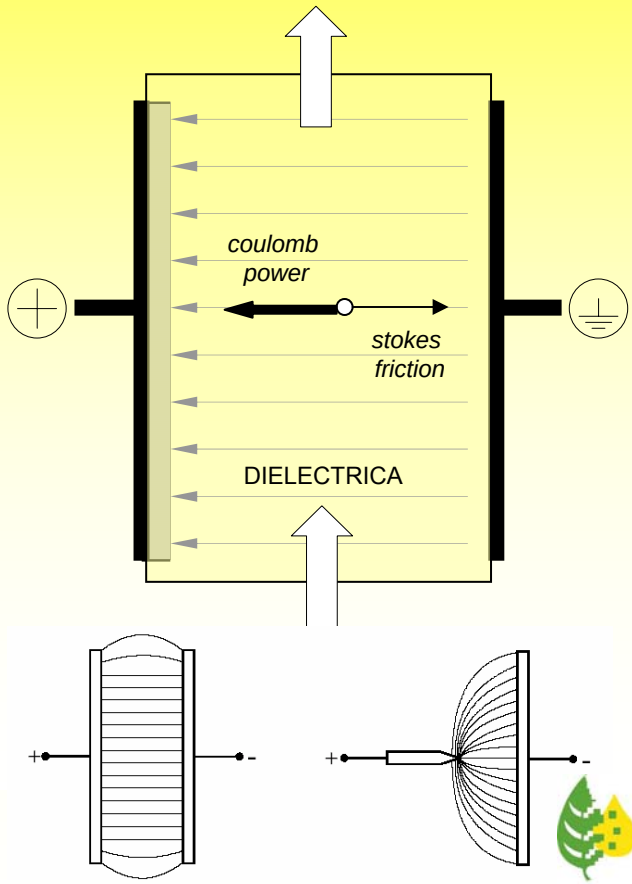
- gas volume flows
- air-cleaning

main components



active principle

DC electric field



circuit diagram air-cleaning device (electrostatic separator)

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Introduction

ELECTRICAL PROPERTIES OF SEVERAL MEDIA

			non dielectric		dielectric media			
Parameter	Symbol	Unit	SEA WATER	TAP WATER	PURE WATER	AIR	PLANT OIL (RAPE)	MINERAL OIL
Conductivity	σ	[S/m]	5.00	0.05	$5.0 \cdot 10^{-6}$	$1.5 \cdot 10^{-12}$	$5 \cdot 10^{-10}$	$< 10^{-10}$
Dielectric Strength	E_d	[kV/mm]	-	-	-	25	20-30	20-50
Permittivity	ε_r	[-]	-	-	80.0	1.0	2.5-3.5(2.8)	2.2-2.5

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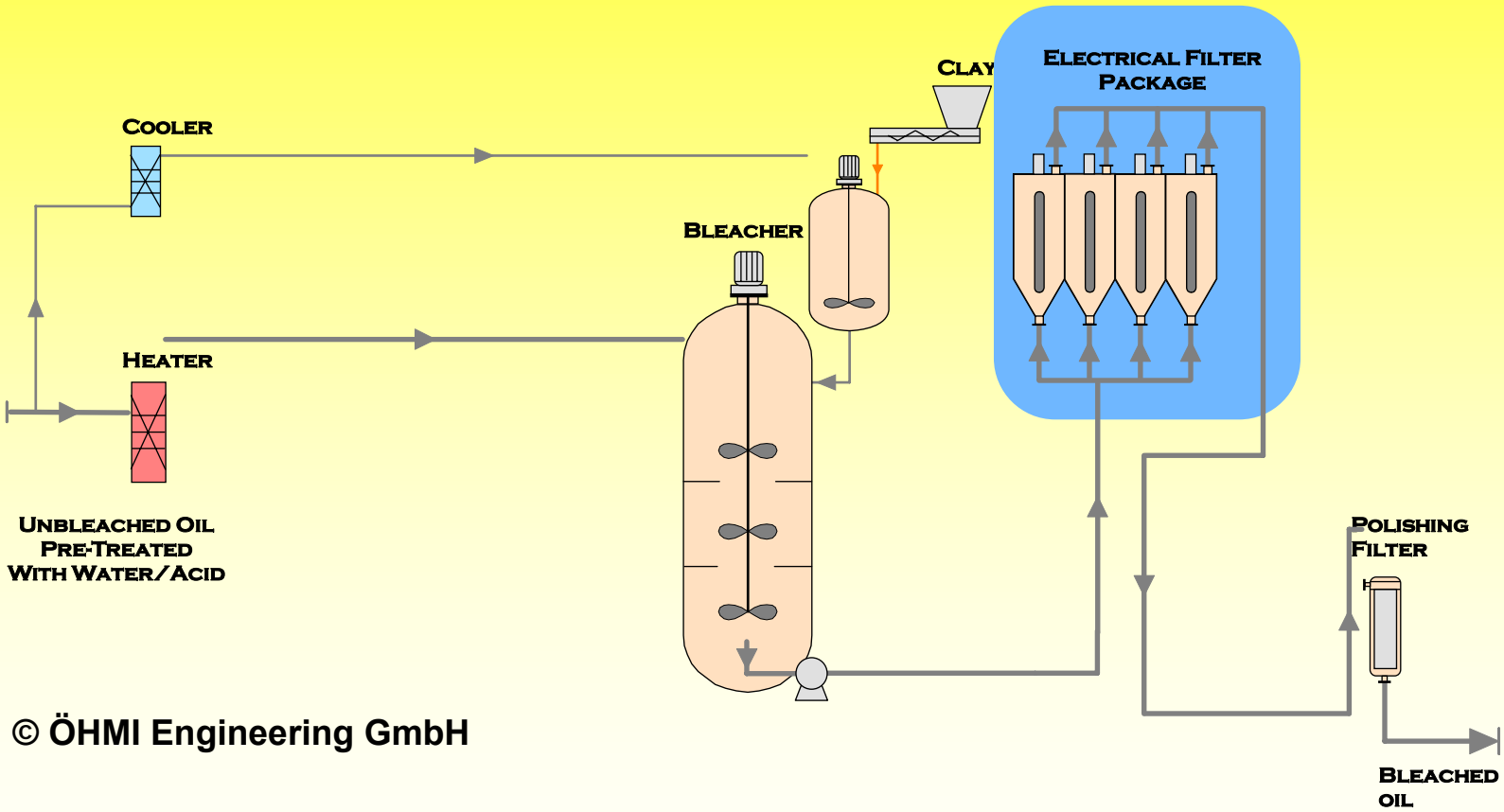
Introduction

ÖHMI FILTRATION PROCESS



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EDIBLE OIL REFINING BY ÖHMI FILTRATION PROCESS

I. Improved bleaching with superfine grained bleaching earth

⇒ **up to 60% reduction of bleaching earth consumption**

application technically hindered by the use of conventional methods for its separation

II. Advantages of electrostatic separation process

Criterion	Electrostatic Separation	Conventional Filtering
Mechanism	cross flow separation	pass through filter flow
Particle size	unlimited, << 1µm	20-40 µm 350 kg oil/m²/h (Patterson, 1992) decrease filtration rate
Filter cycle time	no precoat time, no time for demounting	
Energy consumption	pumps, HV negligible (no current dielectrica)	
Pressure drop	low	

⇒ **lower investment costs**
⇒ **lower operational costs**

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EMERGING PROBLEMS DURING INDUSTRIAL SCALE TESTS

I. Differences in electrostatic separability

⇒ *unacceptable separation*
⇒ *without reference to temperature and viscosity*
⇒ *electroseparation impossible?*
⇒ *critical intrinsic factor?*

II. Adhesive coatings/deposition of bleaching earth (electrode fouling)

⇒ *additional cleaning technology*
⇒ *new design of separator*

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Materials and methods

OIL SPECIFICATIONS

R0
- rape seed oil, fully refined
- commercial available
- product name Vita d' Or
- manufactured by LIDL Austria GmbH

R1
- rape seed oil, partially refined
- Bunge Deutschland GmbH (Mannheim, Germany)
- water degummed

S0
- sun flower oil, fully refined
- commercial available
- product name Vita d' Or
- manufactured by LIDL Austria GmbH

S1
- sun flower oil, partially refined
- Bunge Deutschland GmbH (Mannheim, Germany)
- pre degummed (water)
- no winterisation

S2
- sun flower oil, hot pressed and filtered
- Kroppenstedter Ölmühle Walter Döpelheuer GmbH
- no further refining

BLEACHING CLAYS

TONSIL Optimum 214 FF

TONSIL EX 978 (super fine grained)

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Materials and methods

MEASUREMENT METHODS

Turbidity measurement

Forward scatter turbiditymeter 516
Sensor TF 16 (Optec, Danulat Inc., Essen)
Optical cell with electrodes (1”)

Kinetic of separation

Oil Analyses

Water	[%]	DGF CIII-13a
Waxes	[%]	-
FFA	[mg KOH/g]	DGF C-V 2
SV	[mg KOH/g]	DGF C-V 2
PV	[meg O_2/g]	DGF C-VI 6a
P	[mg/kg]	DGF C-VI 4
Soaps	[%]	DGF C-II 6

Intrinsic factors

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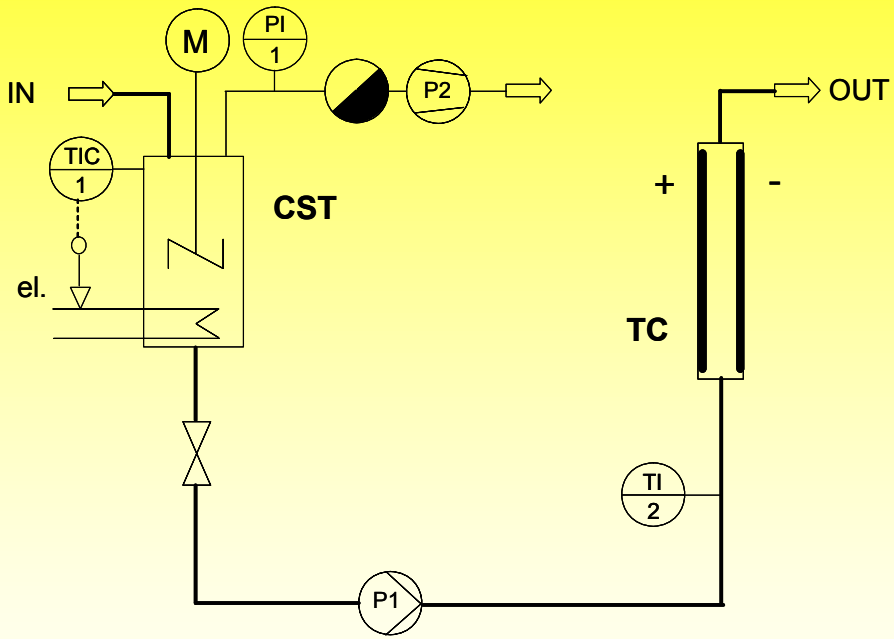
EXPERIMENTAL SETUP



Experimental setup of bleaching and high voltage electroseparation treatment. **CST**: Bleaching unit; **TC**: treatment chamber.

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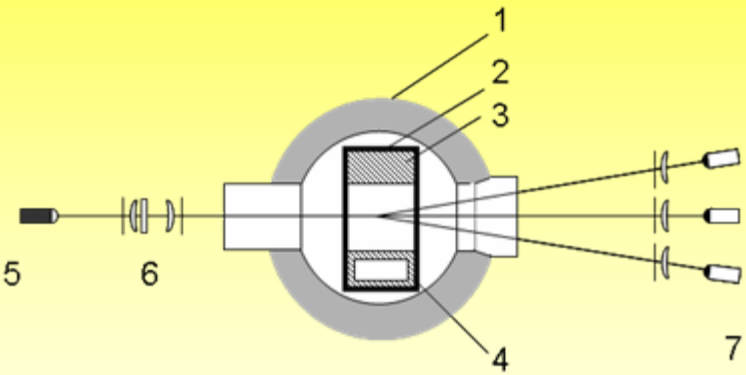
Materials and methods

BATCH CHAMBER

CONTINUOUS CHAMBER



Continuous treatment chamber design (top view). (1) flow-through sensor body with windows; (2) treatment chamber; (3) high voltage electrode; (4) heatable grounding electrode; (5) light source; (6) optic module; (7) photo sensor.

volume	**[cm³]:**	60
electrode area	**[cm²]:**	22.4
E_{max}	**[kV/cm]:**	30

Materials and methods

EXPERIMENTAL PROCEDURE

	PROCESS STEP	PARAMETER	UNIT	
1	Deaeration/Drying	Time	[min]	30
		Temperature	[°C]	90
		Pressure	[mbar]	< 50
		Rotation speed	[min^{-1}]	300
2	Bleaching	Bleaching earth	[%] m/m	0.5
		Time	[min]	20
		Temperature	[°C]	90
		Pressure	[mbar]	< 50
		Rotation speed	[min^{-1}]	200
3	Electroseparation	Time	[s]	~ 20 s
		Temperature	[°C]	70 - 90
		Massflow	[kg/h]	-
		Electric field strenght	[kV/cm]	10 - 30
		Gap	[cm]	1.4 -2.0
		Charging voltage	[kV]	10 - 30

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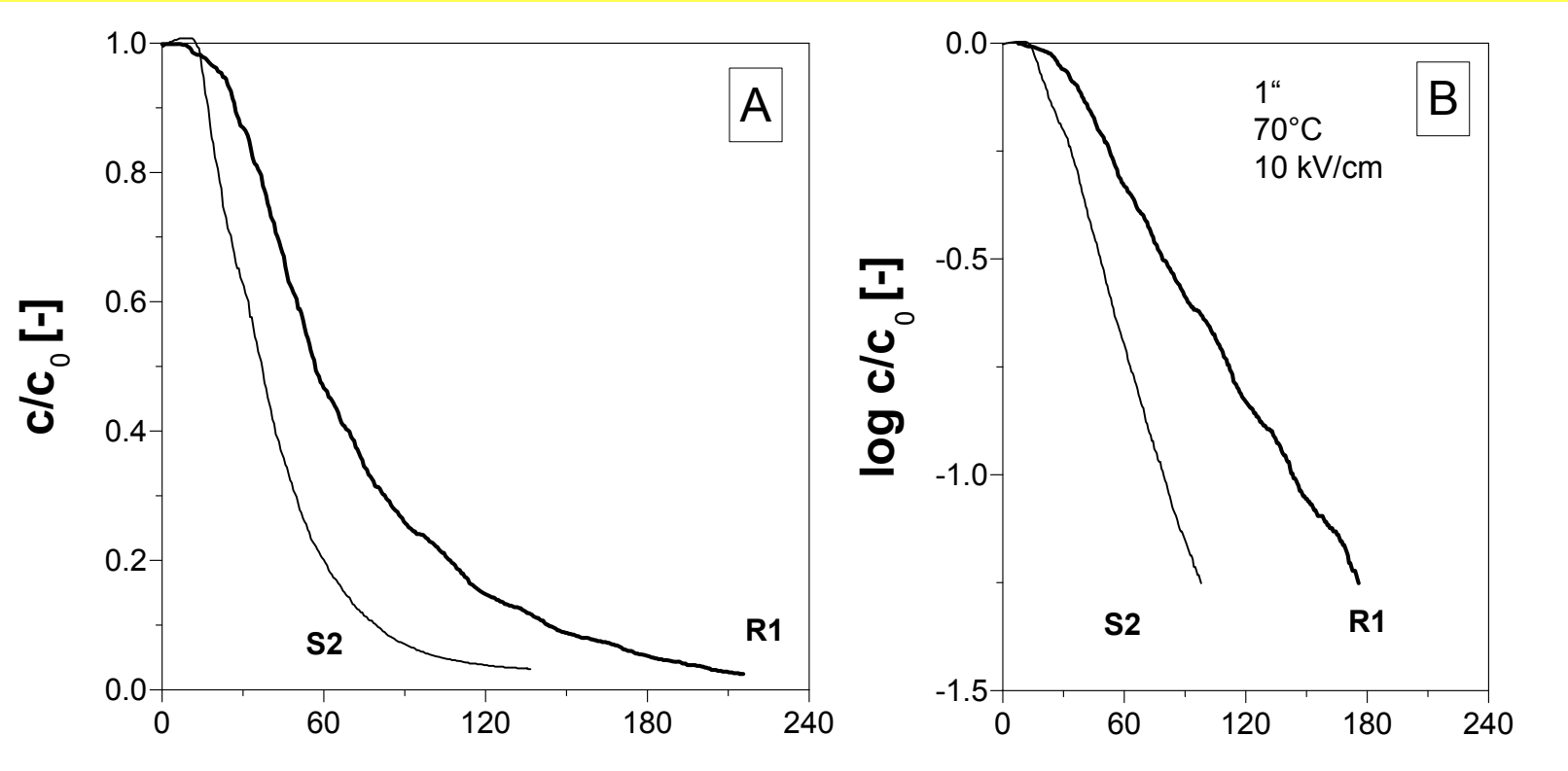
Results and discussion

SUNFLOWER vs. RAPE SEED OIL



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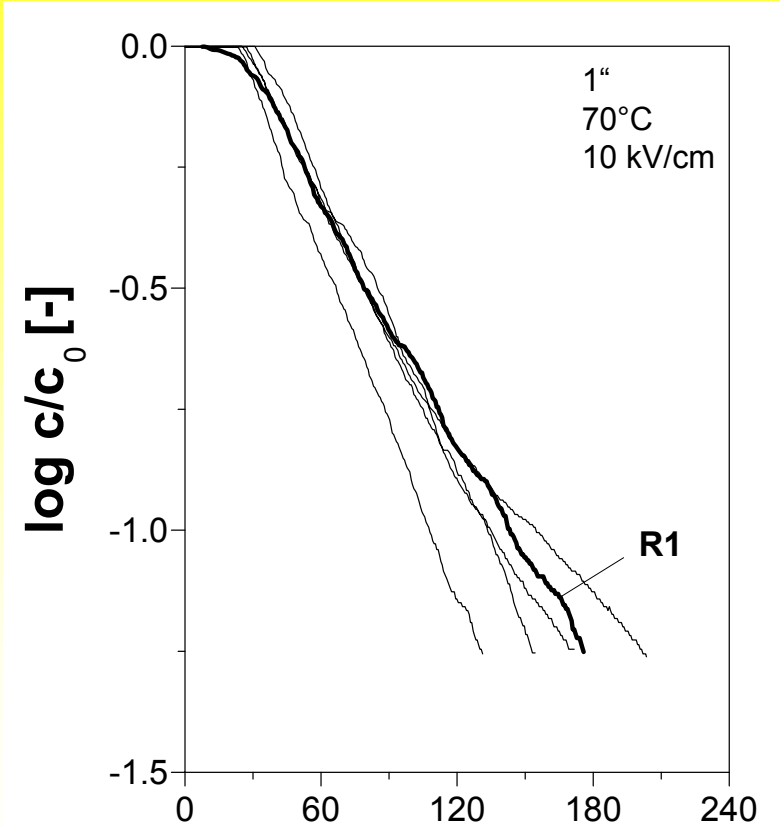
INFLUENCE OF WATER

Quality Attribute	Unit	Method	Rape	Sunflower
			R1	**S2**
W (KF) w	[%]	DGF C-III 13a	0.041	0.070



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INFLUENCE OF WATER

ELECTRICAL CONDUCTIVITY ⟷ free Ions

water

- spontaneous dissociation ionic strength ($H^+ = OH^- = 6.02 \cdot 10^{19}\ m^{-3}$)

$H_2O \rightarrow H^+ + OH^-$

water (indirectly)

- electrolytic dissociation of carbonic acids (ageing dissociation) ($H^+ = OH^- = 6.0 \cdot 10^{23}\ m^{-3}$)

$H\text{-}COOH + H_2O \rightarrow H\text{-}COO^- + H_3O^+$

charge carrier injection (directly)

water hardness

- Ca^{2+}, Mg^{2+} etc.

impurities

temperature ⇒ dissociation acceleration (25 - 90°C = 20-40 fold conductivity)

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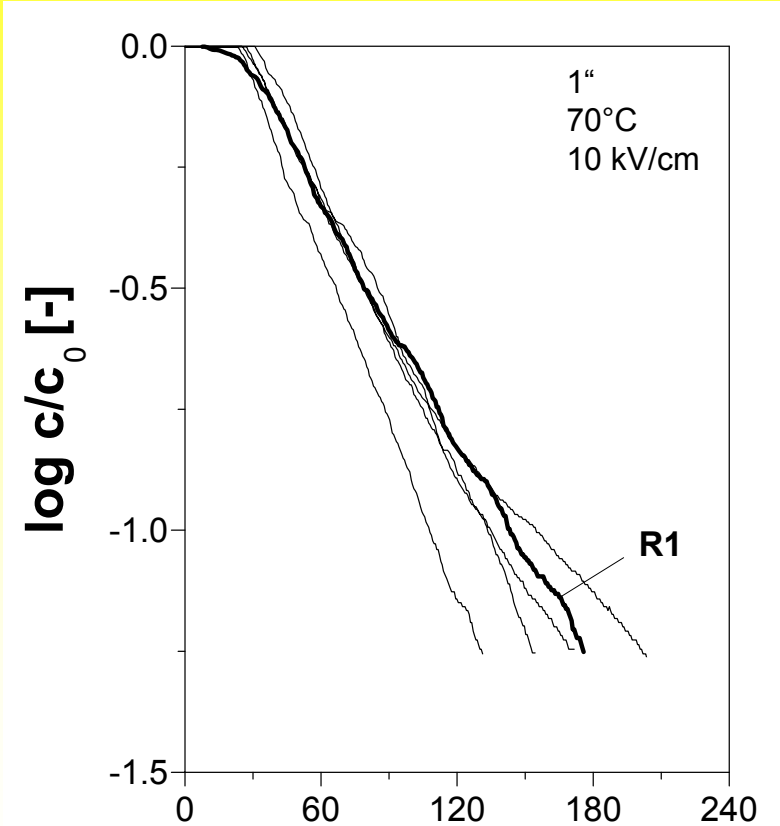
INFLUENCE OF WATER

Quality Attribute	Unit	Method	Rape	Sunflower
			R1	**S2**
W (KF) w	[%]	DGF C-III 13a	0.041	0.070
W (KF) d	[%]	DGF C-III 13a	0.024	0.020

*W (KF) w [%] DGF C-III 13a < 0.08

limit of solubility (Water in oil /100°C): 0.4 w%



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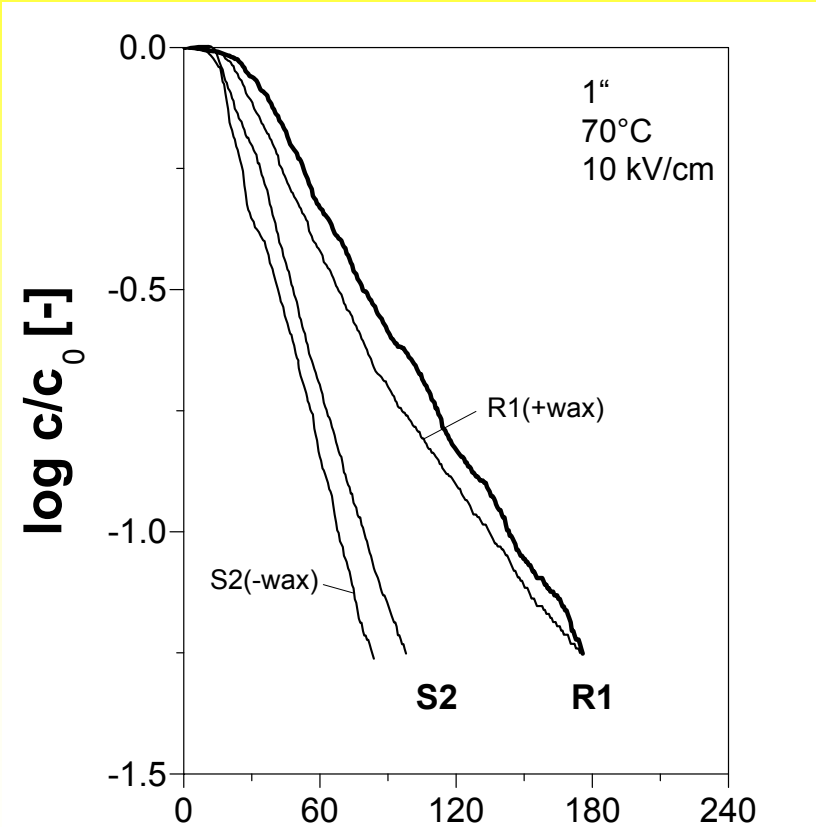
INFLUENCE OF WAXES



200g = 0.8 g = 0.4 Gew. %

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ANALYSIS OF POTENTIALLY RELEVANT OIL PARAMETERS

Quality Attribute	Unit	Method	Rape oil		Sunflower oil		
			R0	**R1**	**S0**	**S1**	**S2**
FFA	[mg KOH/g]	DGF C-V 2	0.34	1.33	0.22	1.50	1.57
SV	[mg KOH/g]	DGF C-V 3	178.2	178.3	181.6	180.5	198.4
PV	[meg O2/g]	DGF C-VI 6a	n. n.	5.15	1.78	12.9	5.28
P	[mg/kg]	DGF C-VI 4	0.9	33.7	1.42	54.7	19.7
S	[%]	DGF C-II 6	-	<0.01	-	-	-

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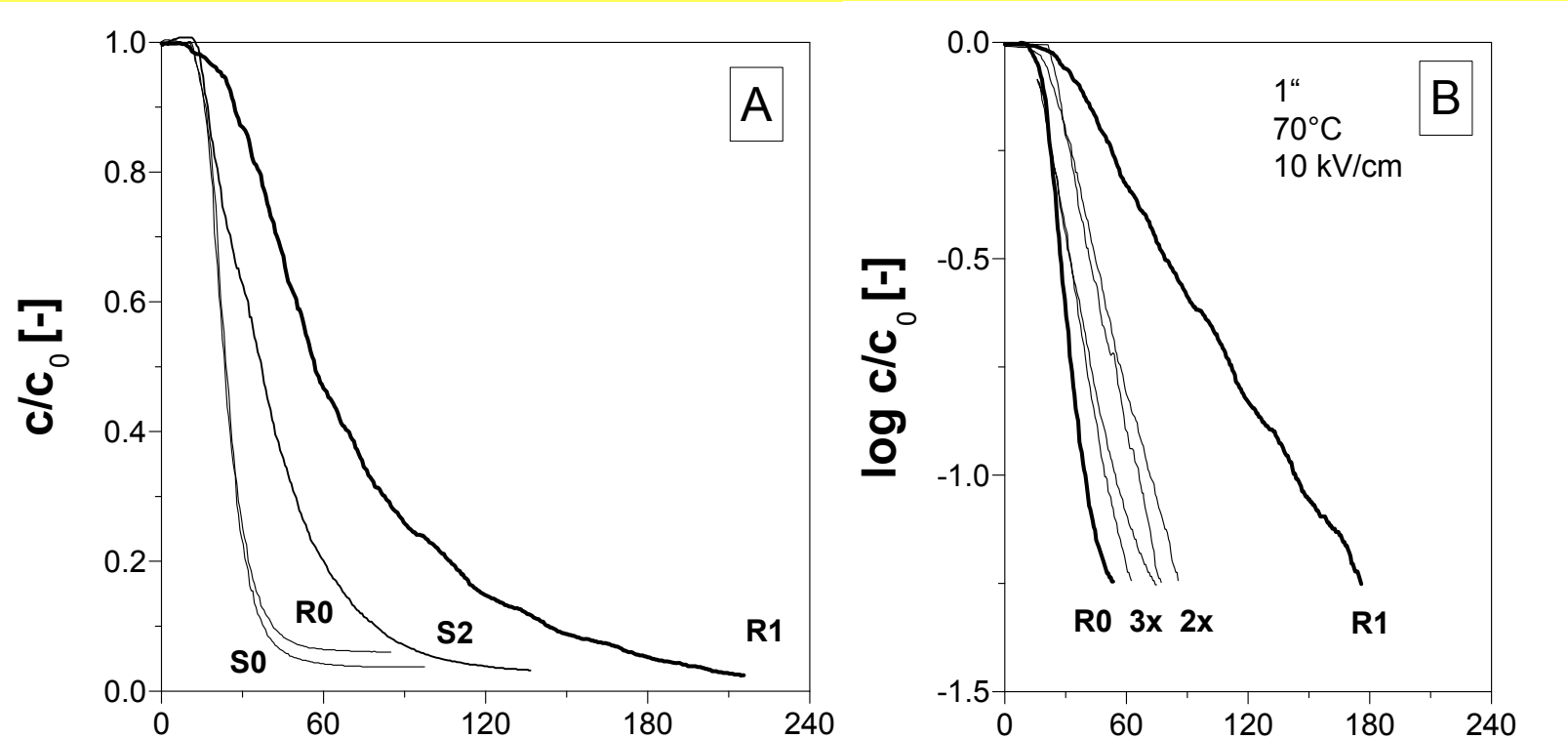
INFLUENCE OF BLEACHING / DEODORISATION



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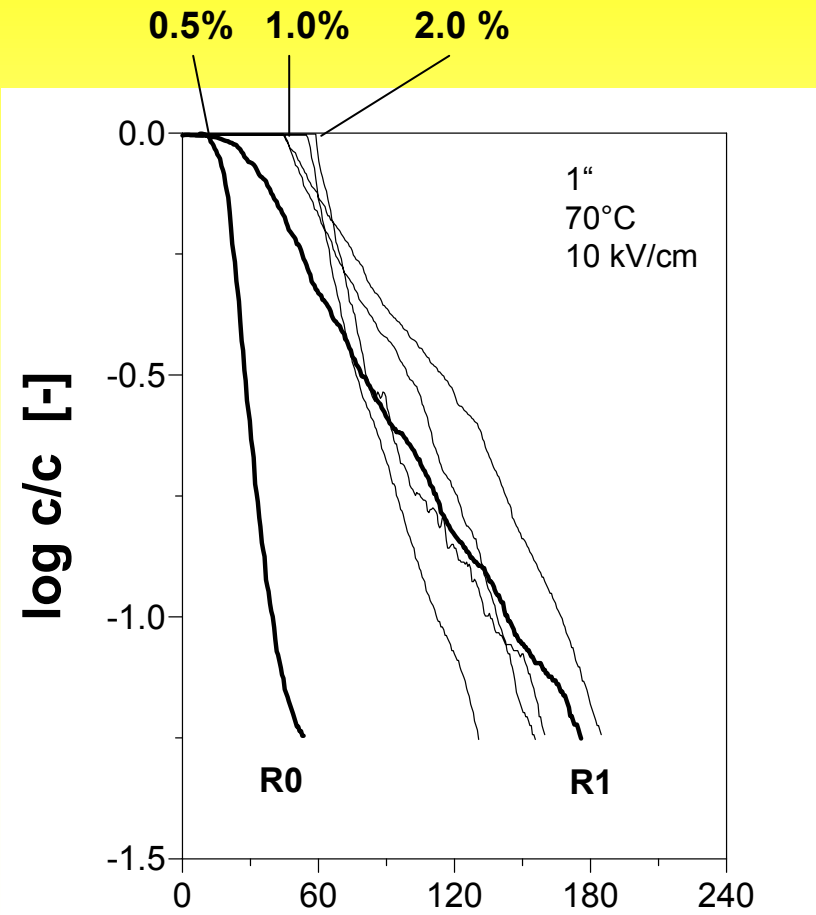
INFLUENCE OF BLEACHING EARTH CONCENTRATION / LOAD



BE > 2%:

Deposition of BE on grounded electrode (transitional state).

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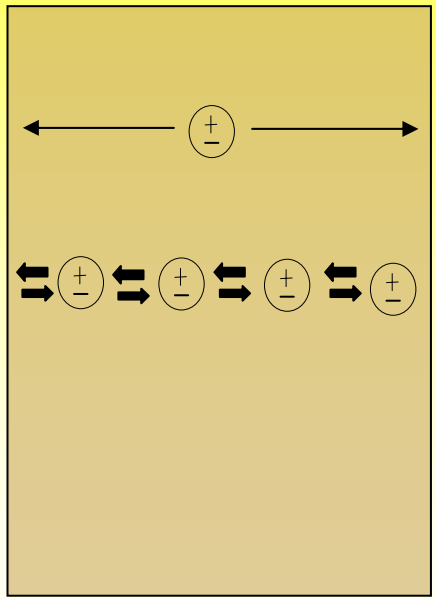
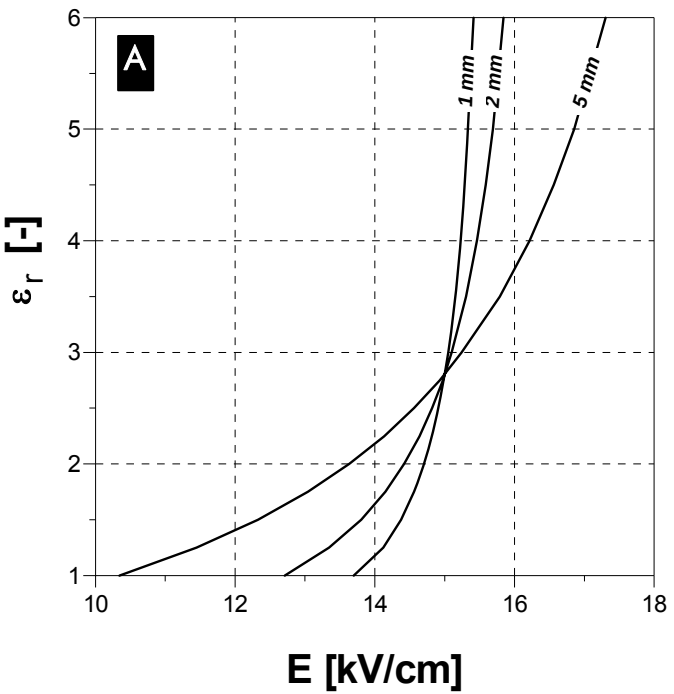
EFFECT OF NO / LOW LOAD

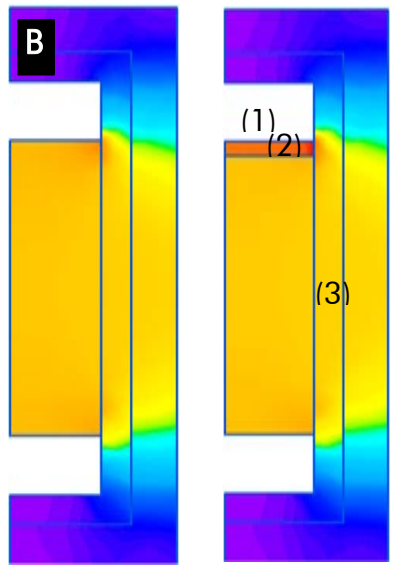
Mineral oil

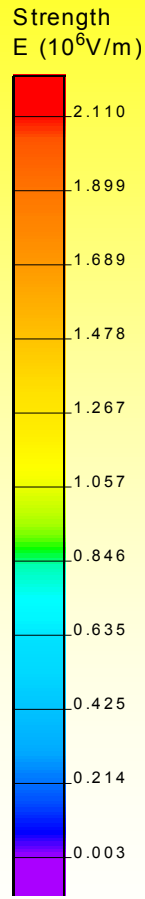


Results and discussion

AVOIDANCE OF ELECTROSTATIC DISCHARGE ON ELECTRODES







Results of electric field computations. Permittivity of dielectric medium [-]: 2.8, Charging voltage [kV]: 30, electrode gap [mm]: 20. (**A**) Influence of permittivity and layer-thickness of different electrode coating materials on the electric field strength. (**B**) Comparison of electric field distribution with and without a 1mm electrode coating from PTFE with ε = 2.2 (quick field simulation). (1) electrode, (2) coating, (3) separation chamber.

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AVOIDANCE OF ELECTROSTATIC DISCHARGE ON ELECTRODES

material	ε_r [-]	E_d [kV/mm]	temperature limit [°C]
Polycarbonate (Makrofol)	2.8	180	100-130
Polyester (Melinex)	3.2	-	125
Polyamide	3.7	30	110-120
Polyester	3.7	80	180

Table: possible coating materials.

Conclusions

1. Electroseparation of bleaching earth from rape seed oil, as well as from other edible oils, is possible.
2. In order to explain the differences between the separation rates in sunflower oil and rape seed oil, the influence of different natural oil ingredients were investigated.
   But, water, waxes and ffa content, saponification and peroxide value as well as phosphorus content alone are not able to influence the separation behavior significantly.
3. Experiments with more fold bleached and fully refined oils showed, that the degree of the oil purity is the crucial factor, which determines the velocity of electric separation.
4. Very low loaded bleaching clays tend to discharge. To improve the process safety by avoiding electron transfer, electrode coating with suitable materials is suggested.
5. In the future, a new separator device with continuous withdraw of the bleaching earth particles is to develop.

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Thank You

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