ELECTRON TREATMENT OF SEED - MOBILE MACHINE CONCEPTS
DEVELOPMENT AND OPERATION

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Content

Short Introduction FEP

State of the art - Seed production

How does Electron Seed Treatment work

Technology today – Application examples
Fraunhofer-Gesellschaft

- is Europe’s largest application-oriented research organization
- was set up in 1949
- 72 institutes and independent research units with 25,000 employees
- the headquarters is located in Munich
- each institute has its own core competences
- the individual institutes act as profit centers on the market

Headquarters in Munich
Forms of Cooperation

- Customer’s product idea
- Research and development
- Key components/organic-electronic devices
- Prototyping
- Pilot production
- Technology transfer
- Licensing
- Customer’s product
Basics of Electron Beam Processing
Technical Basis of Electron Beam Processes

Thermal Processes:
- Micromachining
- Welding
- Hardening
- Perforation
- Evaporation
- Medling

Non-thermal Processes
- Crosslinking
- Modification
- Hardening (e.g. of lacquers)
- Germ reduction
- Disinfection
- Sterilization
Basics of Electron Beam Processes
Non-thermal Applications

Non-thermal processes

Biocidal effects
- Sterilization
- Germ reduction
- Inactivation
- Surface disinfection

Chemical reaction
- Curing
- Crosslinking
- Grafting
- Degradation
Fraunhofer FEP
Non-thermal Applications

Examples

**Polymers**
- Crosslinking
- Hardening
- Grafting
- Functionalization

**Lacquer hardening**
- Bulk goods, sheets, paper, 3D substrates

**Sterilization**

**Waste water Flue gas**
- New machines

**Medical devises**

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Technology today – Application examples
Seed production
State of the art

Breeding
- Cultivation and breeding
  → Basic seed

Propagiation
- Seed propagation/multiplication
  Certification of seed

Seed Treatment
- Seed producers:
  Chemical seed dressing
  - adapted to kind of seed and pathogens

Farming
- Farmers:
  Breeding/Production of cereals, corn, ...
  for feed, food and further production
Seed production
State of the art

SEED TREATMENT – WHY?

- Killing of pathogens → Increase of germination rate, emergence, yield
- Seed treatment: strengthening in most sensible phase (germination)

CHEMICAL SEED DRESSING

- Well established → Worldwide marketing, sale and service
- Overall protection is possible (Soil- and seed-born pathogens)
- Low investment, high running cost

Quelle: Smith/Smith "Elements of Ecology", Pearson Benjamin Cummings, S. 212
Seed production
State of the art

Problems of chemical seed dressing

- **Waste** products in surface water and soil
- Very expensive **registration** and permission procedure for new dressing products
- Year by year less chemical agents are allowed to use
- Drifting of dressing agent **dust** during handling and usage
- Development of **resistant** pathogens and decreasing of efficacy

**DEMAND FOR ALTERNATIVES!!!**
Seed production
State of the art

ALTERNATIVE SEED TREATMENT METHODS

- Biological Seed Treatment
  - Fungus (e.g. *Mhycorrizha*)
  - Bacteria (e.g. *Pseudomonas chloraphis*)
  - Nano-Amendments (e.g. Silicium powder)
  - Organics (e.g. Mustard powder, etheric oils)

- Physical Seed Treatment
  - Hot Water, Hot Steam (ThermoSeed)
  - Microwaves
  - Ultrasonic Steam
  - Plasma
  - Electrons (FEP – Electron Treatment)
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State of the art - Seed production

How does Electron Seed Treatment work

Technology today – Application examples
How does it work

Biocidal effect

DNA line-break (single, double)
change or damage of bases
denaturation
cross linking
adsorption of proteins

ionization

\[ \text{H}_2\text{O} \rightarrow \text{H}_2\text{O}^+ + e_{aq} \quad \text{H}_2\text{O}^+ \rightarrow \text{OH}^- + p^+ \]

decompensation

\[ \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^- \]
How does it works

Basics: Penetration depth

- Calculation of acceleration voltage, depending on
  - Seed shell thickness and density
  - Distance to emitter
- Calculation of current, depending on
  - Aimed dose

\[ S \approx 6.67 \times 10^{-11} \times \frac{(U_B \times k_1)^{5}}{\rho} \times k_2 \]

Quelle: Schiller, Heisig, Panzer: „Elektronenstrahl-Technologie“; FEP, 1995
How does it work

Basic principle

Dose distribution

Relative dose

Perikarp und Testa
How does it work
Electron treatment of seed

- relevant pathogens onto or within the seed coat
- Pathogens inside the seed body and at the embryo can’t be processed
- Cereal seed with *ustilago* affection will not accredited as seed
- *Fusarium* spp. can be treated partially only, but the practical experience is good, the economic significance under German conditions is low
How does it work - Electron treatment of seed

- **Working principle**
  - Acceleration of electrons
  - Gapping and singling of seed

- **Electron shower**
  - All-over exposure by electrons
  - Disinfection of surface layer

- **Cross section**
  - Penetration of episperm by electrons with precise depth control
  - Embryo keeps untouched
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State of the art - Seed production

How does Electron Seed Treatment work

Technology today – Application examples
Technology today – Application examples
First industrial pilot plant

1999: Electron treatment with industrial-like throughput

Type WESENITZ 2
- 2 line emitting sources, 145 kV, 30 kW each
- Continuous treatment on air
- **Throughput:** 30 t/h
- Still under real production
Technology today – Application examples
First stationary production plant

2013: First commercial EB treatment plant
- Type STELLA
- Throughput 30 t/h,
- Fully integrated into seed cleaning, logistic and packaging
Technology today – Application examples
New modulare and flexible machin concept

2018: Type ISABEL, based on 40’ ISO Containers
- Fully automated
- Standardized interfaces
- Easy to integrate
Technology tomorrow – Application examples
Under development

- Medium throughput 5 – 10 t/h
- Compact and flexible
- New type of electron source
- For small facilities

Seed inlet
Control
EB source
Seed outlet
Cooling
Technology today
Application I – Cereal seed

Sold under trademarks: E-PURA, E-VITA

![Bar chart showing the sales of cereal seeds from 2002 to 2014. The chart displays the sales data for different years and indicates the sales under various trademarks.]
Technology today
Application II – Corn

Electron seed treatment at corn

![Graph showing germination rates for different corn varieties with untreated and treated conditions.](image)

- Untreated
- EB-treatment I
- EB-Treatment II

Varieties:
- DKc 3307
- DKc 3390
- DKc 3409
- Logo
- Suleyka
- Kimberly
- Ayrro
- Geox
- Index
- Laurinio
- Pirro
- Isanto
- Devino
- Masetto
- Enormo
Technology today
Application III – Sprouting seed

Fluid culture tests in fertilizer solution

- Seeds inoculated with *E. Coli K12*
- Remarkable reduction of microorganisms

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Seeds inoculated with *E. Coli K12*

Remarkable reduction of microorganisms

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(1) Xuetong Fan, Ph.D.
United States Department of Agriculture
Summary

ADVANTAGES

- Proved effect by long term studies (since 1995) together with BBA (JKI)
- More than 20 years practically experience of farmers in Germany
- Recommendation and ability for ecological farming by EU
- Since 2011 commercial available
- EU recommended treatment alternative to chemical treatment
- Physical treatment, no chemical agents necessary
- No temperature rise of seed during treatment
- No formation of resistant pathogens, contrary to chemical agent treatment
- Treated seed is long term storable without degradation
- No danger to users and environment
Summary

TREATED SEED  HEALTHY GROWING  HEALTHY CEREALS

No impact on soil, ground water or farmer