Electron treatment of seed

- an environmental friendly treatment method with future potential -

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How does it work

History – 25 years of electron treatment

Technology today – Application examples
is Europe’s largest application-oriented research organization
was set up in 1949
66 institutes and independent research units with 22,000 employees all over Germany
the headquarters is located in Munich
each institute has its own core competences
the individual institutes act as profit centers on the market

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Fraunhofer FEP
Fraunhofer Institute Center Dresden

- founded in 1991
- premises: approx. 8,000 m²
- IFAM: Fraunhofer Institute for Manufacturing Technology and Advanced Materials
- IKTS: Fraunhofer Institute for Ceramic Technologies and Systems
- IWS: Fraunhofer Institute for Material and Beam Technology

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**Fraunhofer FEP**

**FACTS and FIGURES**

**FEP (2013)**
- Employees: 141
- Total budget: 17.6 M€
- Industry returns: 7.0 M€
- Investments: 1.4 M€

**COMEDD (2013)**
- Employees: 75
- Total budget: 8.5 M€
- Industry returns: 1.9 M€
- Investments: 0.4 M€

**Director**
- Prof. Dr. Volker Kirchhoff

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Evolution of Surface

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How does it work

History – 25 years of electron treatment

Technology today – Application examples
How does it work
Electron beam technology

THERMAL PROCESSES
- Micromachining
- Welding
- Curing
- Perforating
- Evaporation
- Melting

NON-THERMAL PROCESSES
- Cross-linking
- Modification
- Curing (e.g. of lacquers)
- Germ reduction
- Disinfection
- Sterilization
How does it work
Biocidal effect

- DNA Line-break (single, double)
- Change or damage of bases
- Denaturation
- Cross linking
- Adsorption of proteins

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ionization

\[ \text{H}_2\text{O} \rightarrow \text{H}_2\text{O}^+ + \text{e}^-_{\text{aq}} \]

decomposition

\[ \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^- \]
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
Application at seed

- Acceleration of electrons
- Gapping and singling of seed
- All-over exposure by electrons
- Disinfection of complete surface
- Penetration of episperm by electrons with precise depth control
- Embryo keeps untouched
How does it work
Basic principle

Dose distribution

Relative dose

Perikarp und Testa
Fraunhofer FEP

How does it work

History – 25 years of electron treatment

Technology today – Application examples
History – 25 years of electron treatment

Motivation

- Using of mercury based seed treatment agents was the common practice until the 80th
- Increasing problems with mercury residues in food caused by heavy metal accumulation in soil
- Special economical situation in the former East Germany
- Development of new chemical agents was very expensive
- Searching to new alternative technologies
- Biocidal effect of ionized radiation is well known since 1905
- But penetration sensitive method is necessary, because the embryo has to be untouched
- X-ray and gamma radiation are unfeasible therefore
- First idea of using accelerated electrons was tried 1980 at the private Research institute Manfred von Ardenne
History – 25 years of electron treatment
First testing equipment

**Electron treatment system ELBA 50**
- 1 Scanned electron beam 50 kV
- 1983
- 5 kg batch treatment in rotary screen
- Wheat treatment under vacuum

**Electron treatment system ELBA 60**
- 1 Scanned electron beam 60 kV
- 1987
- Semi-Batch treatment in vacuum in rotary screen

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History – 25 years of electron treatment
Testing equipment for continuous treatment

Pilot plant WESENITZ I
- 2 Scanned EB, 60 kV
- 1995
- Continuous treatment in vacuum
- Throughput: 10 t/h
ELECTRON TREATMENT WITH INDUSTRIAL-LIKE THROUGHPUT

Mobile treatment plant WESENITZ II
- Governmental funded development project
- 1997 - 1999
- 2 line emitting sources, 145 kV
- Continuous treatment on air
- Throughput: 30 t/h
Long term activities for acceptance, marketing and further technology optimization, e. g.:

- Detailed investigation about treatment efficiency together with Julius-Kühn-Institute (German Plant Breeding and Protection Institute) → BBA report
- 2005 general rule for seed acceptance test and treatment analysis by the governmental agricultural agency of Saxony LfL Nossen
- 2005 ability for ecological farming (also at the latest version of Plant Protection Act of Germany)
- 2009 EPPO defines electron treatment as a standard against Tilletia caries and Urocystis occulta
- 2011 selling the mobile pilot-plant WESENITZ 2 to seed producers BayWa AG and Nordkorn Saaten GmbH
- 2012 new brand E-PURA® for electron treated seed by BayWa and Nordkorn
MORE THAN 10 YEARS SUCCESSFUL INDUSTRIAL OPERATION

June 2011 selling the pilot plant to BayWa and Nordkorn for real farming use.

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How does it work

History – 25 years of electron treatment

Technology today – Application examples
Technology today
Application I – cereal seed

Electron-treated seed

Amount [t]


0 2000 4000 6000 8000 10000

approximated

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### Technology today
**Application I – cereal seed**

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Kultur</th>
<th>Wirkung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilletia caries</td>
<td>wheat</td>
<td>excellent</td>
</tr>
<tr>
<td>Urocystis occulta</td>
<td>rye</td>
<td>excellent</td>
</tr>
<tr>
<td>Fusarium spp. Microdochium nivale</td>
<td>wheat, rye, triticale</td>
<td>excellent (wenn erreichbar)</td>
</tr>
<tr>
<td>Septoria nodorum</td>
<td>wheat</td>
<td>very good</td>
</tr>
<tr>
<td>Drechslera graminea</td>
<td>barley</td>
<td>good</td>
</tr>
</tbody>
</table>
Grain yield and emergence of Electron-treated winter wheat

Emergence Ø = 102.6 %
Grain yield Ø = 100.8 %

Chemical treatment = 100 %
Technology today
Application II – corn

Electron seed treatment at corn

Germination rate [%]

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

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ADVANTAGES

- Proved effect by long term studies (since 1995) together with BBA (JKI)
- More than 15 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 by chemical dust
Summary

FURTHER ADVANTAGES
• Not used treated seed will be no hazardous waste, treatment before official seed acceptance possible, more efficient logistics
• Combination with coating processes possible
• Cost efficient and environmental friendly

DEFICITS
• High starting investment
• Emotional reserves at ecological farming in Europe
• No effect against soil borne pathogens – under German conditions practical not relevant

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Summary

FUTURE PROSPECTS

• Increasing infection stress of plants at ecological farming without effective treatment solutions
• Cancelations of chemical agent licences for seed treatment caused by environmental damages
• Resistance problems caused by long term using of chemical agents, marginal new agent development / agent licences
• Increasing infection stress by bacteriological and virale pathogens at seed without effective treatment methods
• EHEC problems (2011)
• CO₂-footprint verification obligation will come in German farming
• Worldwide increasing demand to sensitive hygienic processing of food
Thank you for your attention

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