UV - TECHNOLOGY for Advanced Oxidation Processes in Water & Gas Phases

Frank Seitz

Solutions for the future
Overview

- Basics, Technique & Design
- Brazilian Remediation Projects
- Application in Industry processes and else

Solutions for the future
What is light?

\[ c = f \times \lambda \]

- \( c \): speed of light
- \( f \): frequency
- \( \lambda \): wave length

Light: electromagnetic radiation

Rule: Shorter wavelength, more powerful radiation
Solutions for the future

UV-light

- Browning
- Sunburn
- Disinfection
- Ozone production
- UV polymerisation
- Degradation of pollutants
- Artificial ageing of material

Visible light

Basics – Brazil - Industry
Solutions for the future
Spectral radiation density and radiation intensity of a 4kW Hg-MP lamp
Absorption - Photolysis

Photolysis involves the interaction of light with molecules to bring about their dissociation into fragments. Light is composed of tiny energy packets called photons, whose energy $E$ is inversely proportional to the wavelength, $\lambda$, of the light.

$$E = \frac{hc}{\lambda}$$

where $h$ is Planck's constant and $c$ is the speed of light.

If the absorption of a photon by a molecule is to cause photolysis (dissociation), the photon energy must exceed the energy of the bond to be broken. This requires that the wavelength be in the ultraviolet region of the spectrum for most photolytic reactions. Compounds that absorb UV light and have high quantum yields of photolysis are good candidates for photodegradation. Examples of these classes of compounds include N-nitrosodimethylamine (NDMA) and various chlorinated alkenes and aromatics (i.e. TCE ad PCP). Figure shows the UV absorption spectra for some commonly encountered groundwater contaminants.
Fotochemical effects of UV and VUV irradiation

**Fotoalysis**

Direct fotolysis of Organics: \( R-R + \text{hv} \rightarrow R^\circ + R^\circ \rightarrow \text{CO}_2 + \text{H}_2\text{O} \)

**Ozonolysis**

Activation of oxygen (air): \( \text{O}_2 + \text{hv} \rightarrow \text{O}_3 \)

Fotolysis / homolysis of ozone: \( \text{O}_3 + \text{hv} \rightarrow \text{O}^\circ \)

**Homolysis**

Fotolysis / homolysis of water: \( \text{H}_2\text{O} + \text{hv} \rightarrow \text{OH}^\circ \)

Fotolysis / homolysis of peroxide: \( \text{H}_2\text{O}_2 + \text{hv} \rightarrow \text{OH}^\circ \)
low and middle pressure lamps
low and middle pressure lamps
Electronical power supply for UV lamps

Vorschaltgeräte-technologien

- Magnetisch 50 Hz
- Niederfrequenter Rechteck
- Hochfrequenz

Basics – Brazil - Industry
Solutions for the future
Dimension and operation parameter

- Transmission Quartz
- Transmission Media
- Temperature
- Lamp pressure
- Lampen filling/ -doting
- Aging of lamps
- Electronic supply (kind, current, voltage, frequency)
- Permeation
- Distribution of power
- Flowdynamics
- Combination of techniques
Lab-device

for the implementation of degradation tests with VUV-lamps
Pilot systems for water and gas
Brazil 1 – Pharmaceutical Industry
Brazil 1 - Basic design
Brazil 1 – Calculation of invest and operation costs (total remediation system)
Brazil 1 – Plan of Site
Brazil 1 - Detail design
Brazil 1 – Construction

Basics – Brazil - Industry
Solutions for the future
Brazil 1 - Implementation

Basics – Brazil - Industry
Solutions for the future
Tropicalisation

Basics – Brazil - Industry
Solutions for the future
Brazil 2 – Electronic Industry
Brazil 2 – Calculation of invest and operation costs (components)

UV x Activated Carbon considering change of 6 carbon columns every month

Costs (R$)

Years

Activated Carbon
UV

Basics – Brazil - Industry
Solutions for the future
Brazil 2 – Flow sheet
Brazil 2 – Plan of site

Basics – Brazil - Industry
Solutions for the future
Brazil 2 - Construction
Brazil 2 - Implementation

Basics – Brazil - Industry
Solutions for the future
## Brazil 2 - Efficiency

<table>
<thead>
<tr>
<th>Substance</th>
<th>raw water</th>
<th>after main UV</th>
<th>efficiency</th>
<th>after polishing UV</th>
<th>limits Portaria §18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzoil</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>5,0</td>
<td></td>
</tr>
<tr>
<td>Toluol</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>0,2</td>
<td></td>
</tr>
<tr>
<td>Ethylbenzol</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>0,2</td>
<td></td>
</tr>
<tr>
<td>m-Xylool, p-Xylool</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>0,3</td>
<td></td>
</tr>
<tr>
<td>o-Xylool</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>0,3</td>
<td></td>
</tr>
<tr>
<td>Vinylchlorid (VC)</td>
<td>24,8</td>
<td>0,0</td>
<td>100%</td>
<td>0,0</td>
<td>5,0</td>
</tr>
<tr>
<td>1,1-Dichlorethen (DCE)</td>
<td>592,0</td>
<td>0,0</td>
<td>100%</td>
<td>0,0</td>
<td>30,0</td>
</tr>
<tr>
<td>Methylenechlorid</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>trans 1,2-Dichlorethen</td>
<td>9,8</td>
<td>0,0</td>
<td>100%</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>1,1-Dichlorethen</td>
<td>182,0</td>
<td>71,1</td>
<td>54%</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>cis 1,2-Dichlorethen</td>
<td>1790,0</td>
<td>0,0</td>
<td>100%</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>1,1,1-Trichlorethen</td>
<td>93,7</td>
<td>61,9</td>
<td>22%</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>Tetrachlorokohlenstoff</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>2,0</td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>2,8</td>
<td>2,0</td>
<td>17%</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>1,2-Dichlorethen</td>
<td>0,0</td>
<td>0,0</td>
<td>100%</td>
<td>0,0</td>
<td>10,0</td>
</tr>
<tr>
<td>Trichlorethen (Tri)</td>
<td>1700,9</td>
<td>0,0</td>
<td>100%</td>
<td>0,0</td>
<td>70,0</td>
</tr>
<tr>
<td>Tetrachlorethen (Per)</td>
<td>792,0</td>
<td>0,0</td>
<td>100%</td>
<td>0,0</td>
<td>10,0</td>
</tr>
<tr>
<td>1,1,2-Trichlorethen</td>
<td>0,0</td>
<td>0,0</td>
<td>1,0</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>Chlorbenzol</td>
<td>0,0</td>
<td>0,0</td>
<td>1,0</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>1,1,2,2-Tetrachlorethen</td>
<td>0,0</td>
<td>0,0</td>
<td>1,0</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>sum</td>
<td>5107,1</td>
<td>135,0</td>
<td>97%</td>
<td>0,0</td>
<td></td>
</tr>
</tbody>
</table>

Basics – Brazil - Industry
Solutions for the future
Application

Vacuum-UV-photooxidation systems for purification of water and air

uvibloxFR®

uvibloxFR® GPT

uvibloxFR® WPT

IBL UV-Photooxidation-Systems - Gas Phase Treatment

IBL UV-Photooxidation-Systems - Water Phase Treatment

Basics – Brazil - Industry
Solutions for the future
Elimination of odors (mercaptans, terpenes, butter acid, scatol, amines)

Mineral oil and derivates (alcohols, ketones, aldehydes …)

Methanes

Hydrogen sulfide

Ammonia

Exhaust air from stripping plants

Phenols

CHC (e.g. vinyl chloride, cis-1,2-dichloroethene)

Endocrine substances (antibiotics, zytostatics)

Disinfection

COD, TOC reduction

AHC, PAH, CHC, POL, AOX, PCB

Mineral oil and derivates (alcohols, ketones, aldehydes …)

Cyanides, complexing agents

Endocrine substances (antibiotics, zytostatics)

Pesticides, herbicides, fungicides

Organo phosphite (electroplating)

Trinitrotoluene (TNT) and derivates

Methyltertiarybutylether (MTBE), and more

Disinfection
Scopes of Application

- Remediation
- Municipal waste water treatment
- Potable water treatment
- Waste odour treatment
- Industry:
  - Animal farming
  - Automobile
  - Chemical
  - Electroplating
  - Metal
  - Mineral Oil
  - Pharmaceutical
  - Painting
  - Paper
  - Rubber
  - Vegetable Oil
  - ...

Solutions for the future
Germany – Waste water treatment
Germany – Waste treatment
Germany – Animal husbandry
Germany – Electroplating
Mineral Oil Industry

- Refineries,
- Pump stations,
- Pipelines,
- Tank farms,
- Tank trucks,
- Tank ships...

Contaminated with oil:
- Washing water,
- Rain water,
- Flushing air/vapour
- Groundwater
- …
Germany – Rubber/Metal industry
Japan – Painting Industry
Japan – Paper Industry

Basics – Brazil - Industry
Solutions for the future
Lithuania, Vegetable oil industry
Advantages of \textit{uviblox}®-systems

- Eliminating of contaminants, undesirable odours and micro-organism.
- Low space requirements.
- Easily to be handled, operated, and maintained.
- Low running costs (developed form for reducing cost of energy).
- No more waste after treatment (no increase of organic carbon freight).
- Even for explosive atmospheres/gases (no open flame!).
- Suitable for a wide range of application (small and high concentration):
  - 10 – 100.000 mg/m³
  - 1 – 200.000 m³/h
Cooperation in South America: