WEBINAR: NEW CARBONS, FUTURE APPLICATIONS
Platelet-type carbon nanofibers and their applications

About FutureCarbon: History

Founder: Dr. Walter Schütz
Foundation: 2002, operational since 2004
Focus: Super-Compounds
Place: Germany, Bayreuth - Upper Franconia
...the German Heart of New Materials
Presence

KRAHN
Germany

USA

Benelux

Germany (Bavaria)
Bayreuth, HQ
Munich, Sales

DOU YEE
Pan Asia

Material Base | Value Chain

From raw material to applied product

Material Base
- Carbon Nanomaterials
- Carbon black
- High Tech Graphites

Material Processing
- cleaning
- functionalizing
- homogenizing
- metallization
- delamination/exfoliation

Semi Finished Product
- Material combination
- App specific resins/coatings
- Aqueous & Solvent formula, e.g.
  - Dispersions
  - Resins
  - Coatings
  - Thermoplastics
  - masterbatches

Finished Product
- Carbo e-Therm
- Carbolimpreg
- CarboCond
- CarboDis
- CarboForce
- CarboShield
- Custom Product

Applied Product
- CeT Grid
- CeT Tape

…from **Standard** to **Custom Products** in Mass Volume Scales

+ Application Services
Carbon nanomaterials by FutureCarbon

- Carbon nanotubes
- Carbon nanofibers
  - Platelets
  - Herringbones
  - Screws

**Carbon nanofibers platelet-type (CNF-PL)**

- D: 100-250 nm
- L: 0.5-5 µm
- BET: 120m²/g
Synthesis

- CCVD process (catalytically assisted chemical vapour deposition)

Product
Properties

- Stabilizing surface structure for small particles
- Particularly high oxidation stability
- Hydrothermal stability
- Electrical conductivity
- Further processing possible:
  - Purification
  - Functionalization
  - Annealing
  - ...

Applications

- Additive for electrical conductivity
  - Dispersed in resin
- Catalyst for PEM fuel cells
  - Metallization of CNF-PL
- Catalyst for production of hydrogen from wet biomass
  - Hydrothermal stability
- Graphene production
  - Exfoliation of graphene layers from CNF-PL
CNF-PL as additive for electrical conductivity

- Dispersion in epoxy resin
- Measurement of electrical conductivity after curing
- Comparison of CNF-PL with graphite
- CNF-PL result in higher electrical conductivity than graphite

![Graphite and CNF-PL in epoxy resin](image)

Metallized CNF-PL as catalyst for PEM fuel cells

- Deposition of nano metal particles on CNF-PL
- Metallization process: Colloid microwave processing
- Possible for: Pt, Ru, Pd, Cu, Ag, Fe, Co, Ni
- Platelet shape prevents further growth of metal particles

Developed in collaboration with LS Werkstoffverarbeitung, Univ. Bayreuth
Metallized CNF-PL

- Nano Pt on CNF-PL support
  - TEM (left)
  - SEM (right)

Metallized CNF-PL

- Here: 12 wt% Co on CNF-PL
CNF-PL as catalyst for sustainable fuel production

- Catalyst for hydrogen production from wet biomass
- Current research project “SusFuelCat”
- Goals:
  - Production of almost carbon monoxide free hydrogen
  - Highly active catalyst with high selectivity towards hydrogen
  - Validated long-term stability of catalyst
  - Lowering costs of catalyst
- Hydrothermal stability is important

Test of hydrothermal stability via TGA

CNF-PL is stable at 650°C in N₂/H₂O atmosphere
Graphene production from CNF-PL

- Exfoliation of graphene sheets from CNF-PL
  - Mechanical exfoliation
  - Via intercalation
  - Via supercritical CO$_2$

- Research project “UNCOS”
  - Attempts to exfoliate graphene from CNF-PL
  - Research still ongoing

Mechanical exfoliation

- Grinding, milling, shear mixing…
- Shear mixing of CNF-PL dispersions
- Reduction in length down to 100-200 nm

Before shear mixing

After shear mixing
Mechanical exfoliation combined with intercalation

- Route A: Functionalization of CNF-PL with –NH₂ groups
- Route B: Oxidation of CNF-PL via Hummer’s method
- Shear mixing of CNF-PL dispersions
- No difference compared to non-functionalized CNF-PL for route A

NH₂-functionalized CNF-PL after shear mixing

Graphene exfoliation via supercritical CO₂

- Exfoliation of graphene from graphite via supercritical CO₂
- Independently reported in literature:
  - Zheng et al., RSC Adv. 2012, 2, 10632-10638
Graphene exfoliation via supercritical CO$_2$

- Intercalation by scCO$_2$ with co-solvent
- Mechanical exfoliation by rapid depressurization in scCO$_2$


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Graphene exfoliation via supercritical CO$_2$

- Successful exfoliation of graphite to few-layer graphene in literature
- UNCOS project: Similar setup for CNF-PL -> ? (work ongoing)
Graphene exfoliation via intercalation in solution

- Successful route by Milner et al. with FutureCarbon’s CNF-PL
- Intercalation of CNF-PL with potassium-ammonia solution
- Dissolution in THF yields negatively charged graphene

Acknowledgements

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