GOHAL!: SUSTAINABLE MEMBRANES FOR ALCOHOL DEHYDRATION

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• Fabrication of GO-HAL: new membranes, which consist of graphene oxide (GO) and a humic-acid-like biopolymer (HAL)
• Morphological characterization
• Vapor permeation tests
• Discussion of material and performances
• Conclusions
HUMIC SUBSTANCES

Virtual fragment of aquatic humic acid

Vital resource affecting food chains
- directly
- indirectly (turbidity, pH, metal chelation, …)

Technological properties
- polyelectrolyte
- supramolecular structures, micelles

Availability?
Humic carbon in the oceans is comparable to the amount of the carbon in the atmosphere.

But… diluted (typically mg/L)

S. Mc Donald et al., Analytica Chimica Acta 527 (2004) 105
Among the responsible of membrane fouling
Valorization of the organic urban refuse

V. Boffa PhD thesis, 2010 Turin University (Italy)
Graphene oxide (GO) membranes

Advantages:

• Outstanding water permeability
• High water selectivity
• Easy-to-process

However:

• Low stability under cross-flow filtration
• Thermal densification

GO & HAL

**Chemical similarity:** carbon backbone functionalized with oxygen-containing moieties

**Structural differences:**
- GO → 2D layers
- HAL → 3D branched structure

**Hypotheses:**
- HAL can intercalate GO layers, thus inducing structural **disorder**
- HAL can increase water **permeability** of GO membranes upon thermal stabilization

sustainable membrane material
V. Boffa et. al. *Carbon* 118 (2017) 458
order vs disorder

Starting graphite
d-spacing = 3.35 Å

<table>
<thead>
<tr>
<th>HAL weight fraction (w/w_{tot})</th>
<th>Dried at 45 °C</th>
<th>annealed at 120 °C</th>
<th>annealed at 200 °C</th>
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</tbody>
</table>

Dried at 45 °C
annealed at 120 °C
annealed at 200 °C*

highly disordered
GO-HAL30%

V. Boffa et. al. Carbon 118 (2017) 458
order vs disorder (after annealing at 120 °C)

(a) GO/N

(b) GO-HAL 30%

V. Boffa et. al. Carbon 118 (2017) 458
Membrane water permeability

Annealed at 120 °C

![Graph showing water mass loss and water permeance versus time and HAL weight fraction.]

- **a)** Water mass loss (g) plotted against time (h) for different HAL weight fractions (0%, 2%, 5%, 10%, 30%) and aluminum foil.
- **b)** Water permeance (mol (m² s Pa)⁻¹) plotted against HAL weight fraction (w/w_tot) for dried at 45 °C and annealed at 120 °C.

V. Boffa et al. Carbon 118 (2017) 458
Membrane Perm-selectivity

selective retention of ethanol

good water permeability

V. Boffa et al. *Carbon* 118 (2017) 458
• GO-HAL films were fabricated via a facile process

In summary

• After annealing at 120 °C, GO-HAL 30%:
  • shows stability to dispersion tests in basic solution
  • has water permeance 33% higher than pristine GO
  • shows an ideal water/ethanol selectivity of 45

• Disorder in the GO-structure is a crucial parameter for GO membranes
Is GO-HAL a sustainable membrane material?

Yes, because:

1. Cheap, natural, and abundant starting materials: graphite and organic compost
2. Recycling organic urban waste
3. Easily, scalable and water-based synthesis and processing
4. Heat recovered at the membrane end-of-life

But, there are some challenges:

- Impurities
- New green methods for GO production
- Valorization of the insoluble residue after HAL extraction
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