



Meeting Minutes

MacroFuels WP4 meeting

Date: 2-2-2016

Time: 15.00-17.00

Location: Meeting room 3, Radarport building, Radarweg 60, 1043 NT Amsterdam, The Netherlands

Participants

Name:	Company:
Jaap van Hal	ECN
Wouter Huijgen	ECN
Ed de Jong	Avantium (AVT)
Robert-Jan van Putten	Avantium (AVT)

Agenda

- 1. Task responsibilities within WP4.*
- 2. Distinction between AVT and ECN of research lines.*
- 3. Vision on solely focussing on fuels vs biorefinery approach.*
- 4. Required amount and properties of feedstock materials coming from WP2.*
- 5. Amounts WP4 can produce for WP5.*
- 6. Meeting schedule WP4.*

Minutes of meeting

1. As announced during the general MacroFuels kick-off, the WP4 leader proposes to mutually switch the primary responsibility of tasks 4.3 and 4.4 between ECN and AVT. Task 4.3 focuses on glucose to furans, which is directly in-line with AVT's activities on conversion of C6 sugars to



hydroxymethylfurfural (HMF) ethers, in particular methoxymethylfurfural (MMF). Task 4.4 focuses on conversion of rhamnose (e.g. from *Ulva lactuca*) to 5-methylfurfural, a research topic on which ECN has been acting before. Both parties (ECN and AVT) agree with the proposed change.

2. Both parties have discussed the research lines they want to follow for each task within WP4. They agree on the following distinction of activities related to thermochemical conversion of carbohydrates to furans within WP4: (1) AVT will study conversion of carbohydrates to furans in alcoholic media (task 4.2, 4.3 and 4.4), (2) ECN will study solvent-free (task 4.1) and aqueous (task 4.2 and 4.4) conversion of carbohydrates to furans. AVT will not work on task 4.1 and ECN will not work on task 4.3.
3. Parties have discussed the overall focus of the MacroFuels project as background for their activities in WP4. The project has a clear focus on the production of biofuels from seaweed. However, both parties underline that for economic viability of future production of biofuels from seaweed a (cascading) biorefinery approach seems required. Therefore, co-valorisation of non-carbohydrates (e.g., proteins), specialty carbohydrates (e.g., rhamnose) as well as non-fuel applications of carbohydrates should be addressed to some extent in the project. Parties will explicitly not address these topics by (experimental) research within the project, but will take this issue into account during their work in WP4 by indicating alternative non-fuel outlets of the furans produced, based on the composition of the furan-containing streams produced as well as their general experience in the field.

The focus of the work in WP4 will be on the thermochemical production of furans from various carbohydrates present in seaweeds. More specifically, the research will focus on increasing knowledge on isomerisation and dehydration of seaweed-specific carbohydrates as well as studying matrix effects typical for seaweeds (such as the influence of salts and proteins on the conversion processes).

The end products of WP4, which will be delivered to WP5, are (purified) furans. Derivatisation / further conversion of furans in order to improve their suitability as fuel will not be (experimentally) studied within the project (outside scope). However, since such derivatisation is known to be required in specific cases, such as furfural, derivatisation in these cases is recommended to be taken into account in the system evaluation activities (WP6) and optionally in the fuel evaluation (WP5) using available literature data and previous project experience. Such derivatisation might include, but it not limited to: (a) conversion of furans to aromatics, (b) conversion of furans to 5-methyl furfural (MF), 2-methyl tetrahydrofuran (MTHF) as well as furfuryl methyl ether (FME). For fuel tests (WP5), the selected derivatisation products might be purchased commercially and used for the tests.

4. The required amount and properties of feedstock materials coming from WP2 have been discussed, see table below.

Starting point from DoA: WP2 aims at 10% carbohydrate streams for WP4. This concentration seems too low for conversion activities of AVT. They prefer a syrup (i.e.>50%), unclear whether that will become available within the project. In calculations below a concentration of 30% sugars is assumed.



In addition, AVT asks WP2 partners to provide freeze-dried sugars isolated from seaweeds for exploratory experimental conversion work.

5. The amount of material that will be produced for WP5 has been discussed, see table below.

Seaweed / products	ECN		AVT		Remark
	In (WP2)	Out (WP5)	In (WP2)	Out (WP5)	
Alginate → Furfural (task 4.1)	1 kg/hr (bubbling fluidized bed) (min 100 gr)	~300 gr/hr furfural (min ~30 gr)	NA	NA	Goal: scale-up to kg/hr scale. Start with commercial alginate.
Xylose → Furfural (task 4.2)	100 mL – 20 L autoclaves* → 50 mL – 10 L feed → 15 gr – 3 kg C5 sugars	~5-1000 g furfural	Batch screening in flow. Feed: ~100 mL/hr or 30 gr C5 sugars/hr	~10 gr furfural/hr	AVT is also interested in combined conversion of C5 and C6 (task 4.2 and 4.3).
C6 sugars → HMF / MMF (task 4.3)	NA	NA	Laminarin (from Kelps), Galactose (from red seaweeds), and possibly unsaturated uronic acids (from enzymatic hydrolysis by MATIS). Batch screening in flow will be conducted at same scale as furfural.	Unknown yet (depends on quality of feed and conversion yields)	AVT is interested in testing the influence of C1 on their conversion process.



Rhamnose → 5-methylfurfural (task 4.4)	100 mL – 20 L autoclaves* → 50 mL – 10 L feed → 15 gr – 3 kg rhamnose.	TBD. Expected output 5-1000 gr 5-methylfurfural.	Batch screening in flow will be conducted at same scale as furfural (small effort).	Unknown yet (depends on quality of feed and conversion yields)	
Engine test (task 4.5)	Depending on selected most promising fuel for engine tests.	Depending on selected most promising fuel for engine tests.	To be verified by AVT (amount, sugar concentration, presence of other compounds)	Pilot-plant AVT can produce ~10L MMF (distilled) and possibly ~10L ML**.	Amount needed for fuel test (WP5) is yet unknown.

*) ECN has autoclaves available of 100, 500, 2000 and 20000 mL.

**) Methyl levulinate. To be checked by WP5 whether there is an interest to receive ML for engine tests.

6. Parties agree to have a quarterly WP4 meeting. The next WP4 meeting will be held on Monday June 27th in Reykjavik, Iceland.

Noted by Wouter Huijgen



Action Items:

Action item	WP	Person responsible	Completed by
Organize next WP4 meeting	4	Wouter Huijgen	1-6-2016
Check amount of fuel needed for engine tests by DTI in WP5	5	Jaap van Hal	1-7-2016
Provide AVT freeze-dried sugars isolated from seaweeds for exploratory experimental conversion work.	2	Xiaoru Hou (WP2) / Wouter Huijgen (ECN)	TBD by WP2 (but in 2016)
Feed requirements pilot-plant AVT (amount, sugar concentration, presence of other compounds)	4	Robert-Jan van Putten	1-1-2017
Check by WP5 whether there is an interest to receive ML for engine tests.	5	Jaap van Hal	M30