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Appendices

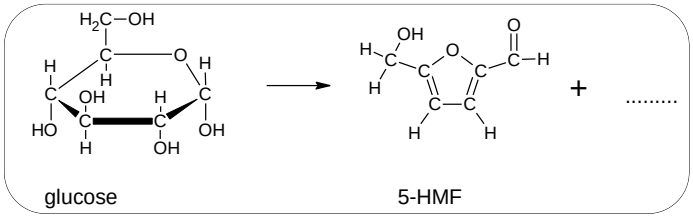
Appendix Chapter 2 (study 1)

Pretest, O1

1. Glucose, $C_6H_{12}O_6$, wordt verbrand. Geef de kloppende reactievergelijking.
2. Een leerling wil de verbrandingsproducten van glucose aantonen met reagentia (= meervoud van reagens). Met welke reagentia kun je de verbrandingsproducten aantonen en wat is/zijn de waarnemingen?
3. Bij de gisting van glucose ontstaan alcohol (=ethanol) en koolstofdioxide. Geef de kloppende reactievergelijking.
4. Als glucose met melkzuurbacteriën in contact komt dan ontstaat melkzuur. Uit één glucosemolecuul ontstaan twee melkzuurmoleculen. Geef de kloppende reactievergelijking.
5. Ontwerp een structuurformule voor melkzuur. Verzin ook tenminste één isomeer van de structuurformule die je hebt ontworpen. Hint: een C-atoom kan 4 bindingen maken; een O-atoom kan 2 bindingen maken. Een H-atoom kan 1 binding aangaan.
6. Bereken de atoomefficiëntie van de omzetting van glucose in melkzuur.
7. Op sommige yoghurtverpakkingen staat te lezen: ‘uitsluitend met rechtsdraaiend melkzuur’. Een dergelijke vermelding op het etiket wekt de indruk dat het hier om iets heel bijzonders gaat en dat deze yoghurt gezonder zou zijn dan een andere yoghurt. Wat wordt er met de term ‘rechtsdraaiend melkzuur’ bedoeld, denk je?
8. Schrijf zoveel mogelijk toepassingen van ‘melkzuur’ op.
9. Wat is volgens jou ‘groene chemie’?

Posttest, O2 en pretest, O3

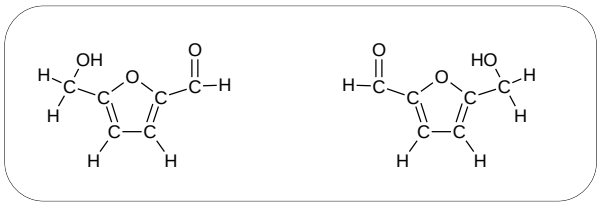
Lees deze bewerking van een Internetbron: Glucose kan onder invloed van enzymen omgezet worden in de stof 5-HMF. Dit is een veelzijdige verbinding, met een hydroxylgroep, een aldehydegroep en de mogelijkheid tot polymerisatie.



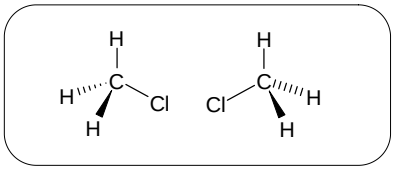
5-HMF kan omgezet worden in 2,5-dimethylfuraan dat een potentiële vloeibare biobrandstof is. In de Internetbron staat: Omdat glucose en 5-HMF afkomstig zijn uit hernieuwbare bronnen (biomassa), hebben ze het potentieel om vergelijkbare stoffen, die uit aardolie afgeleid zijn, te vervangen.

1. Wat betekent de term ‘hernieuwbare bronnen’?
2. Leg uit waarom het belangrijk is dat er vervangende stoffen voor aardolie komen.
3. Hoort de omzetting van glucose in 5-HMF bij groene chemie? Of heb je daarvoor te weinig informatie?

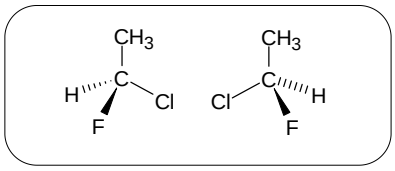
4. In het plaatje hieronder staan 5-HMF en het spiegelbeeld van 5-HMF. Leg uit of hier twee verschillende moleculen staan.



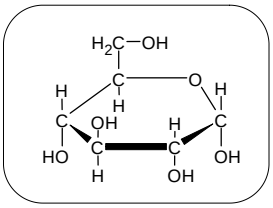
5. Leg uit of de moleculen hieronder spiegelbeeldmoleculen zijn.



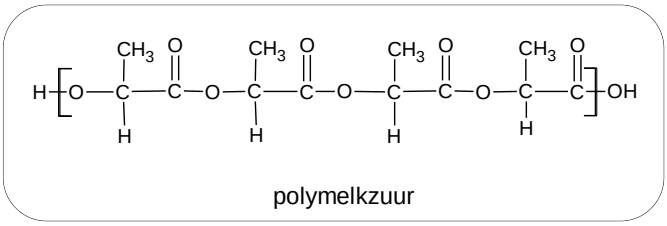
6. Leg uit of de moleculen hieronder spiegelbeeldmoleculen zijn.



7. Hieronder staat de structuurformule van glucose. Zet een sterretje bij de asymmetrische C-atomen.



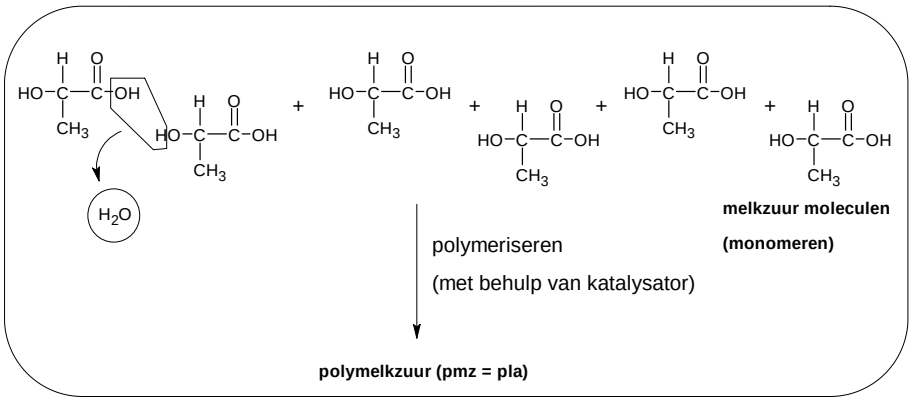
8. Wat is de repeterende eenheid in onderstaande polymeer?



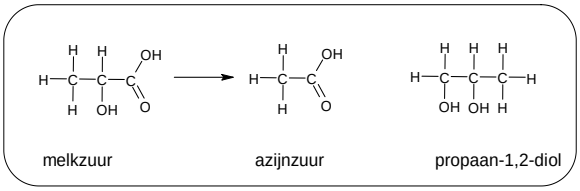
9. Leg uit of er in het polymeer polymelkzuur asymmetrische C-atomen voorkomen. Zo ja, zet een sterretje bij de betreffende C-atomen/het betreffende C-atoom.
10. Polymelkzuur is een thermoharder. Leg uit of deze uitspraak waar of onwaar is.
11. Bij de synthese van polymelkzuur ontstaat water. Het is dus een condensatiereactie. Leg uit of deze uitspraak waar of onwaar is.
12. Polymelkzuur wordt gemaakt uit hernieuwbare grondstoffen. Leg uit of deze uitspraak waar of onwaar is.
13. Polymelkzuur is afbreekbaar. Leg uit of deze uitspraak waar of onwaar is.

Posttest, O4

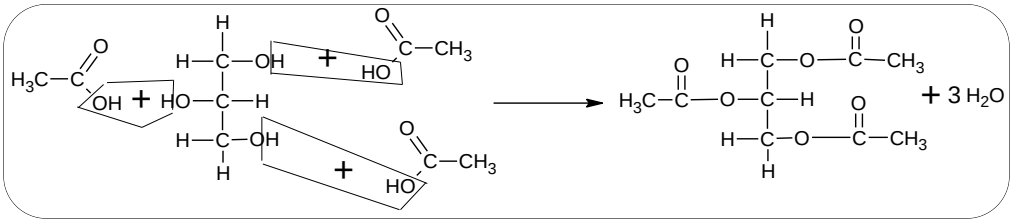
1. Welke stoffen ontstaan als je polymelkzuur verbrandt?
2. Maak de reactievergelijking voor het ontstaan van polymelkzuur verder af. Gebruik structuurformules.



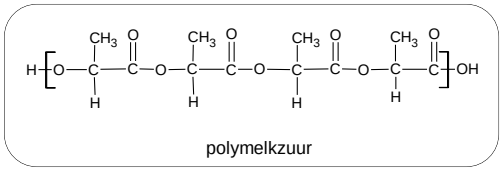
3. Polymelkzuur is afbreekbaar. Leg uit welke voordelen hieraan zitten.
4. Als aan een melkzuuroplossing een bepaalde bacteriestam wordt toegevoegd dan ontstaan o.a. azijnzuur en propaan-1,2-diol. Een leerling zegt dat hij met behulp van azijnzuur en propaan-1,2-diol een polymeer kan maken. Leg uit of deze leerling gelijk heeft.



5. Glycerol kan reageren met azijnzuur. Zie hieronder. Leg uit of hier sprake is van een condensatiereactie.



6. Glycerol kan reageren met azijnzuur. Iemand mengt nu glycerol en propaan-1,2-diol. Leg uit of er nu een condensatiereactie kan komen tussen glycerol en 1,2-propaandiol.
7. Maak een schets van een thermoharder en leg uit wat er gebeurt als je een thermoharder verhit.
8. Wat is de repeterende eenheid in onderstaande polymeer? Omcirkel het betreffende gedeelte.



9. Leg uit of er in het polymeer polymelkzuur asymmetrische C-atomen voorkomen.

Appendix Chapter 3 (study 2)

Vragen die gebruikt zijn bij de semigestructureerde interviews.

1. Hoe ben je enthousiast geworden voor scrum?
2. Welke voordelen zie je voor jouw vak?
3. Scrum bestaat uit veel verschillende elementen. Wat vind je ervan? En… zijn ze noodzakelijk?
    a. Teamvorming
    b. Release planning/Productbacklog
    c. Product-owner
    d. Sprintplanning
    e. Stand-up
    f. Scrum bord
    g. Sprint release/sprint review
    h. Sprint retrospective
4. Heb je alle onderdelen van scrum gebruikt? Waarom wel/niet?
5. Zie je een effect op:
    a. Leeropbrengsten?
    b. Samenwerken?
    c. Eigenaarschap?
    d. Zetten de leerlinge hun kwaliteiten in?
    e. Zelfvertrouwen (in het beheersen van het vak)?
    f. Manier van begeleiden door jou als docent?
6. Wat vinden leerlingen van scrum?
7. Wat vind je niet goed aan scrum?
8. Is scrum geschikt voor alle vakken? Alle onderwerpen? Waarom wel/niet?
9. Wat mis je in scrum?
10. Is scrum wat jou betreft een blijvertje? Waarom wel/niet?
11. Ga je volgend jaar door met scrum? Waarom wel/niet?
12. Wat wil je verder nog kwijt?

Appendix Chapter 4 (study 3)

Vragen gebruikt voor tabel 2 van studie 3, geordend in schalen.

Subject-knowledge expertise:

1. Ik beschik als docent over een goede vakinhoudelijke kennis.
2. Ik hecht veel waarde aan gesprekken met collega's over vakinhoudelijke zaken.
3. Ontwikkelingen in mijn vakgebied houd ik regelmatig bij door zelfstudie en/of scholing.
4. Ik ben erg geïnteresseerd in ontwikkelingen in mijn vak(gebied).
5. Alles wat ik in mijn lessen behandel (over mijn vakgebied) is echt van belang voor de leerlingen.

Didactical expertise:

1. In mijn lessen gebruik ik veel afwisselende werkvormen.
2. Ik zorg ervoor dat leerlingen hun leer- of werktijd effectief gebruiken.
3. Ik ondersteun mijn lessen zoveel mogelijk met hulpmiddelen.
4. Ik evalueer mijn onderwijs regelmatig.
5. Ik besteed in mijn lessen veel aandacht aan het vaststellen en verhelpen van problemen van leerlingen bij het leren.
6. De keuze van relevante leerstof voor leerlingen neemt veel van mijn tijd in beslag.

Pedagogical expertise:

1. Als docent ben ik een voorbeeld voor de manier waarop leerlingen met elkaar en met anderen omgaan.
2. Ik stimuleer bewust een goede omgang tussen leerlingen.
3. Als ik probleemgedrag van leerlingen bemerk, probeer ik daar iets aan te doen.
4. Voorop staat bij mij dat ik een klimaat in mijn klassen wil hebben waarin leerlingen zich veilig en gewaardeerd voelen.
5. In mijn lessen ben ik nadrukkelijk bezig met persoonlijkheidsvorming.
6. Het beeld dat leerlingen van zichzelf hebben, is een belangrijk uitgangspunt voor de manier waarop ik leerlingen benader.

Vragen gebruikt voor tabel 3 van studie 3, geordend in schalen.

Teaching context:

1. Voor mijn functioneren als leraar is het belangrijk dat de schoolorganisatie goed is.
2. Voor mijn functioneren als leraar is het belangrijk dat onze school inspeelt op onderwijskundige vernieuwingen.
3. Ik vind het belangrijk om ontwikkelingen in mijn vak(gebied) te betrekken bij mijn lessen.
4. Ik vind het voor mijn functioneren als docent belangrijk dat in onze school mogelijkheden worden geboden tot bij- en nascholing.
5. Samenwerking met collega's vind ik belangrijk voor mijn eigen functioneren als docent.
6. Voor mijn functioneren als leraar vind ik het belangrijk dat onze school zorg besteedt aan de begeleiding van leerlingen met leerproblemen.

Teaching experiences:

1. Belangrijk aan onderwijservaring is dat ik daardoor kan inspelen op onverwachte gebeurtenissen in de klas.
2. Belangrijk aan onderwijservaring is dat ik daardoor kan inspelen op onverwachte gebeurtenissen in de klas.
3. Belangrijk aan onderwijservaring is dat ik daardoor de meeste lessen niet of nauwelijks meer hoef voor te bereiden.
4. Belangrijk aan onderwijservaring is dat ik daardoor weet wat mijn sterke en zwakke kanten als docent zijn.

Biography:

1. Belangrijk aan onderwijservaring is dat ik daardoor weet wat mijn sterke en zwakke kanten als docent zijn.
2. Mijn manier van lesgeven is beïnvloed door een of meer goede docenten van wie ik vroeger zelf les kreeg.
3. Normen en waarden die ik naleef, stemmen overeen met de normen en waarden die ik voor mijn leerlingen belangrijk vind.
4. De manier waarop ik thuis ben opgevoed, is van invloed op de manier waarop ik met de leerlingen omga.
5. Ik ben door mijn naaste familie of vrienden gestimuleerd om leraar te worden.

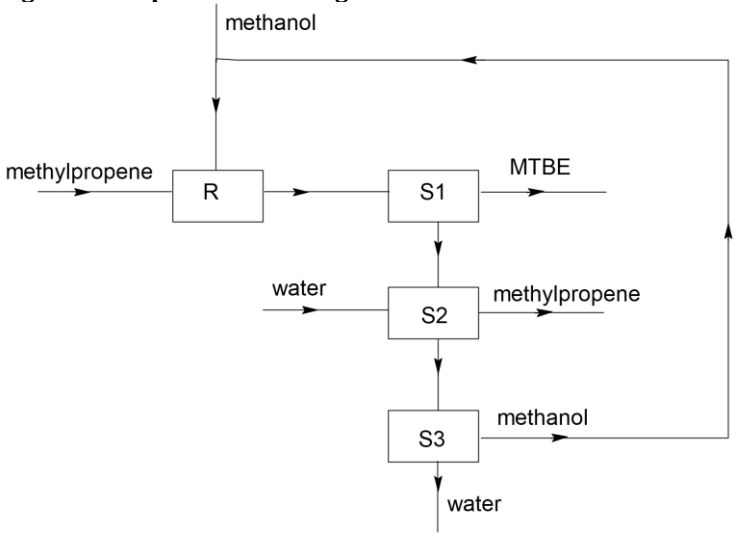
Appendix Chapter 5 (study 4)

Pre-test / post-test items of the GCCT-test (23 points).

1. Explain what is meant with the word 'sustainability' (1 point).
2. Write down as many of the characteristics of Green Chemistry you are aware of (3 points).
3. Describe what is meant with reaction yield (1 point).
4. Provide a description of E-factor (1 point).
5. A manufacturer wants to produce a specific chemical. It turns out that there are two different synthesis routes available. Method 1 has an atom efficiency of 50%, whereas method 2 has an atom efficiency of 75%. *Explain* which method is preferable (2 points).

   Methyl-tert-butyl ether (MBTE, $C_5H_{12}O$) is added to petrol to increase its anti-knock rating. MTBE is synthesized from methyl propene (C_4H_8) and methanol (CH_3OH).
6. Explain whether this reaction is an addition reaction (2 points).
7. Calculate the E-factor. Assume that the yield of the reaction is 100% (2 points).
8. In an experiment a researcher started with 20 g methyl propene and an excess of methanol. Finally, she isolated 30 g pure MTBE. Calculate the yield of the reaction (3 points).
9. Calculate the reaction-enthalpy of the MTBE synthesis. Given: the heat of formation of MTBE = $- 3{,}2 \cdot 10^5$ $J.mol^{-1}$ (3 points). The industrial production of MTBE is represented in this simplified block diagram (Figure 1).

Figure 1. Simplified block diagram.



In reactor R methyl propene and an excess of methanol are mixed. In this situation all substances are liquid. The mixture that leaves reactor R consists of methanol and traces of methyl propene. In three successive steps (S1, S2 and S3) the mixture is separated in MTBE, methyl propene and methanol. For the separation step S2 water is added.

10. Explain on micro level what happens in S2 (1 point).
11. In S3 water and methanol are separated. Methanol is recycled. Explain whether the process in S3 is endothermic or exothermic (2 points).
12. Why is it necessary to add extra methanol during the reaction process (2 points)?

Pre-test / post-test items van de QAM-questionnaire.

Self-efficacy

1. Ik vertrouw erop dat ik de lesstof kan leren (onder knie krijg)
2. Ik ben in staat om het lesmateriaal te snappen
3. Ik denk dat ik de toetsen voor scheikunde goed kan maken na afloop van de lessenserie
4. Ik vertrouw erop dat ik scheikunde ga beheersen
5. Ik kan het schoolvak scheikunde toch niet (let op: omgekeerd geformuleerd)
6. Ik kan bij scheikunde geen goede cijfers halen (let op: omgekeerd geformuleerd)

Self-regulation

1. Ik ga voor scheikunde uit mezelf aan het werk tijdens de les
2. Ik houd mezelf goed aan het werk voor dit vak
3. Ik werk hard voor scheikunde
4. Ik heb het werk voor scheikunde op tijd af
5. Ik doe mijn best om scheikunde zo goed mogelijk te begrijpen
6. Ik wil het werk voor scheikunde op tijd afhebben
7. Ik voel me verantwoordelijk voor mijn werk voor scheikunde
8. Ik werk niet volgens planning bij scheikunde (omgekeerd geformuleerd)

Classroom climate

1. Ik merk dat ik bij de scheikundelessen veel keuzemogelijkheden krijg om mijn werk te doen
2. Ik leer veel in de lessen omdat ik foute antwoorden bespreek in de groep (of met de leraar)
3. Ik voel me bij scheikunde prettig in de klas
4. Ik vind de werksfeer bij scheikunde uitstekend
5. Ik vind dat er in de les hard gewerkt wordt voor scheikunde
6. Ik leer van de fouten die ik tijdens de lessen maak

Personal development

1. Ik krijg bij scheikunde inzicht in mijn kwaliteiten
2. Ik leer bij scheikunde mijn eigen kwaliteiten kennen
3. Ik ontwikkel bij scheikunde mijn eigen kwaliteiten
4. Ik groei in zelfvertrouwen bij scheikunde
5. Ik leer bij scheikunde mijn eigen kwaliteiten inzetten

Attitude towards chemistry

1. Ik heb plezier in het schoolvak scheikunde
2. Ik ga door het schoolvak scheikunde met plezier naar school
3. Ik vind scheikunde erg leuk omdat de inhoud me erg aanspreekt
4. Ik vind het schoolvak scheikunde belangrijk
5. Ik heb geen interesse in het schoolvak scheikunde (let op: omgekeerd geformuleerd).

Collaboration

1. Ik help mijn teamgenoten tijdens groepswerk
2. Ik vind samenwerking bij scheikunde nuttig
3. Ik werk bij scheikunde goed samen met mijn teamgenoten
4. Ik functioneer bij scheikunde goed in een team

Appendix Chapter 6 (study 5)

Post-test items (pre-test item (see study 4)).
The main-items listed below were used for both synthesis routes. Each item was divided in sub-items with separate scores. In total there were 40 items (46 points).

1. Design a detailed block-diagrams, for multi-step synthesis route 1 and for synthesis route 2. Include recirculation of substances if applicable (10 points).
2. Provide equations for all reaction steps of synthesis route 1 as well as for route 2 (7 points).
3. Calculate the atom economy for synthesis route 1 and synthesis route 2 (7 points).
4. Calculate the E-factor for synthesis route 1 and route 2. Take into account the reaction yields as provided in the description of the module (6 points).
5. Distinguish potential waste-products and discuss their impact on the E-factor (for both route 1 & route 2) (5 points).
6. Discuss the hazardousness of all substances involved in route 1 and route 2 (4 points).
7. Calculate the reaction enthalpy for route 1 and route 2. Use heats of formation as provided in the module (7 points).

Eindopdracht

(gebaseerd op de module Groene Chemie (Jansen-Ligthelm et al., 2010).

Binnen een straal van 10 km van jullie school wordt een chemische fabriek, die adipinezuur gaat vervaardigen, gepland. Adipinezuur kan via twee syntheses/productieroutes bereid worden. Jullie ontvangen over beide productieroutes informatie. Er wordt door de buurtraad van jullie een advies gevraagd over een voorkeur voor één van de twee routes. Uiteindelijk hebben jullie meer verstand van scheikunde dan de gemiddelde burger. Jullie groep bestaat uit ongeveer 4 personen. Allereerst moeten jullie je verdelen in twee subgroepen.
De ene subgroep gaat voor het eerste proces onderstaande opdracht uitvoeren, de tweede subgroep doet dit voor het tweede proces. Vervolgens overleggen jullie gezamenlijk om tot een beargumenteerd eindoordeel/ aanbeveling te komen.

De opdracht luidt:
Breng een beargumenteerd advies uit aan de buurtraad. Hiervoor moet je de volgende deelopdrachten maken:

- Neem het proces door.
- Geef het proces weer in een blokschema.
- Stel de reactievergelijking op voor het totale proces.
- Bereken de atoomeconomie
- Bereken de E-factor in het geval dat de bijproducten niet gebruikt kunnen worden.

- Zoek op of er toepassingen bestaan voor de bijproducten en geef aan of dit invloed heeft op de grootte van E.
- Doe een beargumenteerde uitspraak over de vervuilingscoëfficient Q
- Bereken Δ E voor het hele proces.
- Bekijk het proces door de ogen van een “groene” chemicus aan de hand van de twaalf principes van de groene chemie. Deel per principe een ++, +, 0, - of -- uit.
- Na overleg met de andere groep leerlingen kun je onderstaande tabel invullen. Deze kan jullie o.a. helpen om tot een beargumenteerde keuze te komen.
- Kom tot deze keuze en beschrijf deze keuze in een geschreven advies.

Overlegtabel.

Principe	Route 1	Route 2	Toelichting
1. Preventie • Is er sprake van vervuiling? • Zijn bij de recycling extra processtappen nodig?			
2. Atoomeconomie			
3. Minder gevaarlijke chemische productiemethode • Zijn er gevaarlijke stoffen betrokken bij het proces?			
4. Ontwikkelen van minder schadelijke chemische stoffen			
5. Veiliger oplosmiddelen			
6. Energie efficiënt ontwerpen • Vinden de processen bij hoge temperatuur plaats? • Vergelijk het energie-effect van de twee processen (exotherm en endotherm).			
7. Gebruik hernieuwbare grondstoffen			
8. Reacties in weinig stappen • Tel aantal reactie- en zuiverings-stappen.			
9. Katalyse			
10. Ontwerpen met het oog op afbraak			
11. Preventie milieuverontreiniging • Denk aan uitstoot van stoffen			
12. Minder risicovolle chemie			

Appendix Chapter 6 (study 5) *continued*

Two characteristic excerpts extracted from the written advices.

SOLO level (sub-level)	Score	Examples from the written advices of students	Explanation
Multi-structural (High)	4	Finally, they wrote: *We advise route 2 for several reasons. It does not use solvents, there are fewer steps, and a catalyst is used. Chemicals are less hazardous. Although that the atom efficiency is lower, when we combine our findings, we think that route 2 is eco-friendlier.*	For each synthesis route this group used the 12 principles. They described their opinion for all the 12 aspects. Therefore, their advice could be rated with at least 4 points. However, they made some calculations errors (e.g. atom efficiency was miscalculated). For all principles, they combined data for both routes. However, they made no connections between different principles. They did not reach the relational level. In addition, sometimes their argumentation was incomplete or wrong. Both raters awarded this advice with 4 points.
Relational (High)	7	*The final score of route 1 is -7, whereas route 2 scores +9. Obviously, synthesis route 2 is preferable. This route has fewer reaction steps, uses less harmful chemicals, waste products are biodegradable and its chemistry is overall less hazardous. In addition, route 1 is more expensive. It comprises corrosive chemicals and therefore there is a need for stainless reactors. On the other hand, route 2 is still in its infancy. A lot of research is necessary whether there are alternatives in the form of cheaper and/or reusable chemicals. Route 2 can only gain, and therefore we choose route 2: synthesis of adipic acid from cyclohexene with hydrogen peroxide.*	This group compared the two synthesis routes by awarding points (++/+/0/-/--) to all twelve principles. They explained their argumentations carefully, including correct calculations and to-the-point descriptions. This group *compared* both synthesis routes and applied their data to new situations (e.g. corrosive chemicals require expensive stainless reactors). They critically reflected on the preferred route and suggested some alternatives. They did not connect their advice to their personal lives or other societal issues. Both raters awarded this advice with 7 points.