Comparative assessment of an alternative route to (5-benzylfuran-3-yl)methanol (Elliott’s alcohol), a key intermediate for the industrial production of resmethrins.

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Electronic Supporting Information

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Substances’ data used for EATOS calculations

EATOS Output

Route A. Existing route (EP 0 187 345, 1986)
- Atom Selectivity (AS) of Route A
- E-factor of Route A: 183.1 kg waste/kg product
- Environmental Impact of Waste (EI_out) of Route A: 696.65 PEI units/kg product
- Environmental Impact of Feedstock (EI_in) of Route A: 248.49 PEI units/kg product

Route B. Alternative route (this paper)
- Atom Selectivity (AS) of Route B
- E-factor of Route B: 101.98 kg waste/kg product
- Environmental Impact of Waste (EI_out) of Route B: 401.63 PEI units/kg product
- Environmental Impact of Feedstock (EI_in) of Route B: 196.38 PEI units/kg product

Graphical comparison of three indexes (E, EI_out, and EI) for both routes

According to substance category
According to synthetic step

Details of substances’ data

Data from the Osiris tool (www.organic-chemistry.org)
## Substances’ data used for EATOS calculations\(^a\)

<table>
<thead>
<tr>
<th>Name</th>
<th>Price €</th>
<th>Size</th>
<th>Risk phrases</th>
<th>TWA</th>
<th>Hazard</th>
<th>Acute tox.</th>
<th>Type</th>
<th>Chronic tox</th>
<th>WGK</th>
<th>LC50</th>
<th>BCF/logP</th>
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\(^a\) Taken from the 2007 Aldrich catalogue, the TOXNET Hazardous Substance DataBank (HSDB), the European Chemical Bureau (ECB), and the OSIRIS tool @ www.organic-chemistry.org
<table>
<thead>
<tr>
<th>Name</th>
<th>Price €</th>
<th>Size</th>
<th>Risk phrases</th>
<th>TWA</th>
<th>Hazard</th>
<th>Acute tox.</th>
<th>Type</th>
<th>Chronic tox</th>
<th>WGK</th>
<th>LC50</th>
<th>BCF/logP</th>
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</table>
Atom Selectivity (AS) of Route A

Route A:

step 6 (Route A):
AS (of the following synthesis): 53.0%, AS (of the synthesis sequence): 14.0%
1 Diacetoxyisoxazoline + 2 Potassium hydroxide 85% --> 1 Isoxazoline diol + 2 Potassium acetate

step 5 (Route A 5):
AS (of the following synthesis): 80.0%, AS (of the synthesis sequence): 20.9%
1 Diacetoxyisobutene + 1 Oxime + 1 NaOCl 10% --> 1 Diacetoxyisoxazoline + 1 NaCl + 1 Water

further syntheses addendum to step 5:
appendant to Oxime (Substrate):
AS (of the following synthesis): 55.7%, AS (of the synthesis sequence): 55.7%
2 Phenylacetaldehyde + 2 Hydroxylamine Hydrochloride + 1 Sodium carbonate --> 2 Oxime + 1 Carbon dioxide + 2 Sodium chloride + 3 Water

step 4 (Route A 4):
AS (of the following synthesis): 59.6%, AS (of the synthesis sequence): 15.0%
1 3-Chloro-2-chloromethyl-1-propene + 2 Sodium acetate --> 1 Diacetoxyisobutene + 2 NaCl

step 3 (Route A 3):
AS (of the following synthesis): 60.8%, AS (of the synthesis sequence): 12.7%
1 Trichloroacid --> 1 3-Chloro-2-chloromethyl-1-propene + 1 CO2 + 1 Hydrogen chloride

step 2 (Route A 2):
AS (of the following synthesis): 46.3%, AS (of the synthesis sequence): 20.9%
1 Trichloro + 4 Nitric acid 65% --> 1 Trichloroacid + 2 NOx + 3 Water

step 1 (Route A 1):
AS (of the following synthesis): 26.2%, AS (of the synthesis sequence): 26.2%
1 Pentaerythritol + 3 Thionyl chloride + 3 Pyridine --> 1 Trichloro + 3 Pyridine + 3 Sulfur dioxide + 3 Hydrogen chloride
E-factor of Route A: 183.1 kg waste/kg product

According to synthetic step:
step 6  ( 19.47 (10.64%) of 183.1)
step 5  ( 80.80 (44.13%) of 183.1)
step 4  (  3.18 ( 1.74%) of 183.1)
step 3  (  0.71 ( 0.39%) of 183.1)
step 2  ( 55.33 (30.22%) of 183.1)
step 1  ( 23.61 (12.89%) of 183.1)

According to substance category:
Sewage/Water   ( 76.07 (41.55%) of 183.1)
Auxiliaries (isolation) ( 52.17 (28.49%) of 183.1)
Solvents       ( 31.42 (17.16%) of 183.1)
Substrates     (  3.83 ( 2.09%) of 183.1)
By-products    (  8.16 ( 4.45%) of 183.1)
Coupled products (11.19 ( 6.11%) of 183.1)

E/Route A:
Sewage/Water (76.07 (41.55%) of 183.1):
step 6 (Route A):
  out of solvent EtOH
    Water
      Mass: 2.42
  out of auxiliary material Hydrochloric acid (37%aq)
    Water
      Mass: 0.61

step 5 (Route A 5):
  out of substrate NaOCl 10%
    Water
      Mass: 18.29
  out of auxiliary material NaCl; Sodium chloride (aq, conc.)
    Water
      Mass: 6.10

Further syntheses appendant to step 5:
  appendant to Oxime (Substrate):
    out of auxiliary material Washing water (as Water separately)
Water
Mass: 5.35

step 2 (Route A 2):
out of substrate Nitric acid 65%
Water
Mass: 2.11

out of auxiliary material Washing water (as Water separately)
Water
Mass: 12.12

out of auxiliary material NaOH 1M
Water
Mass: 16.00

out of auxiliary material Hydrochloric acid (37%aq)
Water
Mass: 1.14

step 1 (Route A 1):
out of auxiliary material Washing water (as Water separately)
Water
Mass: 11.96

E/Route A:

Auxiliaries (isolation) (52.17 (28.49%) of 183.1):
step 6 (Route A):
Hydrochloric acid (37%aq)
Loss: 0.36

Dichloromethane
Loss: 11.49
Recoverable thereof: 9.19

step 5 (Route A 5):
Dichloromethane
Loss: 17.95
Recoverable thereof: 14.36
NaCl; Sodium chloride (aq, conc.)
  Loss: 2.03

Magnesium sulfate
  Loss: 0.68

further syntheses appendant to step 5:
  appendant to Oxime (Substrate):
    Washing water (as Water separately)
      Loss: 0.00

step 2 (Route A 2):
  Washing water (as Water separately)
    Loss: 0.00

NaOH 1M
  Loss: 0.67

Hydrochloric acid (37%aq)
  Loss: 0.67

Dichloromethane
  Loss: 18.06
  Recoverable thereof: 14.45

Magnesium sulfate
  Loss: 0.27

step 1 (Route A 1):
  Washing water (as Water separately)
    Loss: 0.00

E/Route A:
Solvents( 31.42(17.16%) of 183.1 )

step 6 (Route A):
  Water
    Loss: 2.31

EtOH
Loss:                           1.21
Recoverable thereof:            0.97

step 5 (Route A 5):
   Dichloromethane
   Loss:                            20.19
   Recoverable thereof:             16.15

further syntheses appendant to step 5:
   appendant to Oxime (Substrate):
      Ethanol
         Loss:                              1.87
      Water
         Loss:                              3.72

step 4 (Route A 4):
   Acetonitrile
   Loss:                              2.12
   Recoverable thereof:              1.70

E/Route A:
Substrates( 3.83(2.09%) of 183.1 ):
step 6 (Route A):
   Potassium hydroxide 85%
      Excess:                         0.05
      (*Utilized mass (pure):         0.57*)
      (*Converted mass:               0.52*)

step 5 (Route A 5):
   Oxime
      Excess:                         0.46
      (*Utilized mass (pure):         1.37*)
      (*Converted mass:               0.91*)

   NaOCl 10%
      Excess:                        1.53
      (*Utilized mass (pure):         2.03*)
      (*Converted mass:               0.50*)

further syntheses appendant to step 5:
appendant to Oxime (Substrate):
Hydroxylamine Hydrochloride
    Excess: 0.15
    (*Utilized mass (pure): 0.89*)
    (*Converted mass: 0.74*)

Sodium carbonate
    Excess: 0.11
    (*Utilized mass (pure): 0.68*)
    (*Converted mass: 0.57*)

step 4 (Route A 4):
Sodium acetate
    Excess: 0.11
    (*Utilized mass (pure): 1.30*)
    (*Converted mass: 1.18*)

step 2 (Route A 2):
Nitric acid 65%
    Excess: 1.28
    (*Utilized mass (pure): 3.91*)
    (*Converted mass: 2.63*)

step 1 (Route A 1):
Thionyl chloride
    Excess: 0.11
    (*Utilized mass (pure): 6.65*)
    (*Converted mass: 6.54*)

    Pyridine
    Excess: 0.02
    (*Utilized mass (pure): 4.37*)
    (*Converted mass: 4.35*)

E/Route A:
By-products (8.16(4.45%) of 183.1):
step 6 (Route A):
    Unknown by-products:
        Loss: 0.03
step 5 (Route A 5):
  Unknown by-products:
  Loss: 0.83

further syntheses appendant to step 5:
appendant to Oxime (Substrate):
  Unknown by-products:
  Loss: 0.13

step 4 (Route A 4):
  Unknown by-products:
  Loss: 0.13

step 3 (Route A 3):
  Unknown by-products:
  Loss: 0.13

step 2 (Route A 2):
  Unknown by-products:
  Loss: 1.16

step 1 (Route A 1):
  Pentaerythritol tetrachloride
  Loss: 0.78

  Unknown by-products:
  Loss: 4.97

E/Route A:
Coupled products (11.19(6.11%) of 183.1):
step 6 (Route A):
  Potassium acetate
  Loss: 0.89
  (*Total mass: 0.89*)

step 5 (Route A 5):
  NaCl
  Loss: 0.27
Water
Loss: 0.08
(*Total mass: 0.08*)

further syntheses appendant to step 5:
appendant to Oxime (Substrate):
Carbon dioxide
Loss: 0.22
(*Total mass: 0.22*)

Sodium chloride
Loss: 0.59
(*Total mass: 0.59*)

Water
Loss: 0.27
(*Total mass: 0.27*)

step 4 (Route A 4):
NaCl
Loss: 0.79
(*Total mass: 0.79*)

step 3 (Route A 3):
CO2
Loss: 0.32
(*Total mass: 0.32*)

Hydrogen chloride
Loss: 0.26
(*Total mass: 0.26*)

step 2 (Route A 2):
NOx
Loss: 1.44
(*Total mass: 1.44*)

Water
Loss: 0.42
(*Total mass: 0.42*)

step 1 (Route A 1):

Pyridine
Loss: 2.48
(*Total mass: 2.48*)

Sulfur dioxide
Loss: 2.01
(*Total mass: 2.01*)

Hydrogen chloride
Loss: 1.14
(*Total mass: 1.14*)
Environmental Impact of Waste (EI_out) of Route A: 696.65 PEI units/kg product

According to synthetic step:
step 6  ( 90.50 (12.99%) of 696.65)
step 5  (319.41 (45.85%) of 696.65)
step 4  ( 15.16 ( 2.18%) of 696.65)
step 3  (  2.92 ( 0.42%) of 696.65)
step 2  (183.85 (26.39%) of 696.65)
step 1  ( 84.80 (12.17%) of 696.65)

According to substance category:
Sewage/Water ( 76.07 (10.92%) of 696.65)
Auxiliaries (isolation) (333.38 (47.85%) of 696.65)
Solvents (161.54 (23.19%) of 696.65)
Substrates ( 21.64 ( 3.11%) of 696.65)
By-products ( 47.90 ( 6.88%) of 696.65)
Coupled products ( 54.70 ( 7.85%) of 696.65)

EI_out/Route A:
Sewage/Water ( 76.07 (10.92%) of 696.65):
step 6 (Route A):
  out of solvent EtOH
    Water
      (Q=1)
      Mass: 2.42 --> 2.42
  out of auxiliary material Hydrochloric acid (37%aq)
    Water
      (Q=1)
      Mass: 0.61 --> 0.61

step 5 (Route A 5):
  out of substrate NaOCl 10%
    Water
      (Q=1)
      Mass: 18.29 --> 18.29
  out of auxiliary material NaCl; Sodium chloride (aq, conc.)
    Water
      (Q=1)
      Mass: 6.10 --> 6.10
further syntheses appendant to step 5:
  appendant to Oxime (Substrate):
   out of auxiliary material Washing water (as Water separately)
   Water
     (Q=1)
     Mass: 5.35 --> 5.35

step 2 (Route A 2):
  out of substrate Nitric acid 65%
  Water
    (Q=1)
    Mass: 2.11 --> 2.11
  out of auxiliary material Washing water (as Water separately)
  Water
    (Q=1)
    Mass: 12.12 --> 12.12
  out of auxiliary material NaOH 1M
  Water
    (Q=1)
    Mass: 16.00 --> 16.00
  out of auxiliary material Hydrochloric acid (37%aq)
  Water
    (Q=1)
    Mass: 1.14 --> 1.14

step 1 (Route A 1):
  out of auxiliary material Washing water (as Water separately)
  Water
    (Q=1)
    Mass: 11.96 --> 11.96

EI_out/Route A:
Auxiliaries (isolation)(333.38(47.85%) of 696.65):
step 6 (Route A):
  Hydrochloric acid (37%aq)
    (Q=5.0; Q_human tox.(50.0%)=6; Q_ecotox.(50.0%)=4)
    Loss: 0.36 --> 1.79
Dichloromethane
(Q=6.7; Q_human tox.(33.3%)=3; Q_chron. tox.(33.3%)=10; Q_ecotox.(33.3%)=7)
Loss: 11.49 --> 76.59
Recoverable thereof: 9.19 --> 61.27

step 5 (Route A 5):
Dichloromethane
(Q=6.7; Q_human tox.(33.3%)=3; Q_chron. tox.(33.3%)=10; Q_ecotox.(33.3%)=7)
Loss: 17.95 --> 119.64
Recoverable thereof: 14.36 --> 95.72

NaCl; Sodium chloride (aq, conc.)
(Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
Loss: 2.03 --> 5.08

Magnesium sulfate
(Q=3.0; Q_human tox.(50.0%)=2; Q_ecotox.(50.0%)=4)
Loss: 0.68 --> 2.03

further syntheses appendant to step 5:
appendant to Oxime (Substrate):
Washing water (as Water separately)
(Q=1)
Loss: 0.00 --> 0.00

step 2 (Route A 2):
Washing water (as Water separately)
(Q=1)
Loss: 0.00 --> 0.00

NaOH 1M
(Q=5.5; Q_human tox.(50.0%)=7; Q_ecotox.(50.0%)=4)
Loss: 0.67 --> 3.67

Hydrochloric acid (37%aq)
(Q=5.0; Q_human tox.(50.0%)=6; Q_ecotox.(50.0%)=4)
Loss: 0.67 --> 3.33
Dichloromethane
\( Q=6.7; \ Q_{\text{human tox.}}(33.3\%)=3; \ Q_{\text{chron. tox.}}(33.3\%)=10; \ Q_{\text{ecotox.}}(33.3\%)=7 \)
Loss: \( 18.06 \rightarrow 120.42 \)
Recoverable thereof: \( 14.45 \rightarrow 96.34 \)

Magnesium sulfate
\( Q=3.0; \ Q_{\text{human tox.}}(50.0\%)=2; \ Q_{\text{ecotox.}}(50.0\%)=4 \)
Loss: \( 0.27 \rightarrow 0.82 \)

step 1 (Route A 1):
Washing water (as Water separately)
\( Q=1 \)
Loss: \( 0.00 \rightarrow 0.00 \)

EI_out/Route A:
Solvents( 161.54(23.19\%) of 696.65 ):
step 6 (Route A):
Water
\( Q=1 \)
Loss: \( 2.31 \rightarrow 2.31 \)

EtOH
\( Q=3.0; \ Q_{\text{human tox.}}(50.0\%)=2; \ Q_{\text{ecotox.}}(50.0\%)=4 \)
Loss: \( 1.21 \rightarrow 3.63 \)
Recoverable thereof: \( 0.97 \rightarrow 2.90 \)

step 5 (Route A 5):
Dichloromethane
\( Q=6.7; \ Q_{\text{human tox.}}(33.3\%)=3; \ Q_{\text{chron. tox.}}(33.3\%)=10; \ Q_{\text{ecotox.}}(33.3\%)=7 \)
Loss: \( 20.19 \rightarrow 134.60 \)
Recoverable thereof: \( 16.15 \rightarrow 107.68 \)

Further syntheses appendant to step 5:
appendant to Oxime (Substrate):
Ethanol
\( Q=3.0; \ Q_{\text{human tox.}}(50.0\%)=2; \ Q_{\text{ecotox.}}(50.0\%)=4 \)
Loss: \( 1.87 \rightarrow 5.60 \)
Water
step 4 (Route A 4):
Acetonitrile
\( (Q=5.5; Q_{human\ tox.}(50.0\%)=4; Q_{ecotox.}(50.0\%)=7) \)
Loss: 2.12 --> 11.68
Recoverable thereof: 1.70 --> 9.34

EI_out/Route A:
Substrates(21.64(3.11%) of 696.65):
step 6 (Route A):
Potassium hydroxide 85%
\( (Q=5.5; Q_{human\ tox.}(50.0\%)=7; Q_{ecotox.}(50.0\%)=4) \)
Excess: 0.05 --> 0.30

step 5 (Route A 5):
Oxime
\( (Q=1) \)
Excess: 0.46 --> 0.46

NaOCl 10%
\( (Q=7.7; Q_{human\ tox.}(33.3\%)=6; Q_{chron.\ tox.}(33.3\%)=10; Q_{ecotox.}(33.3\%)=7) \)
Excess: 1.53 --> 11.72

further syntheses appendant to step 5:
appendant to Oxime (Substrate):
Hydroxylamine Hydrochloride
\( (Q=7.0; Q_{human\ tox.}(50.0\%)=4; Q_{ecotox.}(50.0\%)=10) \)
Excess: 0.15 --> 1.05

Sodium carbonate
\( (Q=4.5; Q_{human\ tox.}(50.0\%)=5; Q_{ecotox.}(50.0\%)=4) \)
Excess: 0.11 --> 0.51

step 4 (Route A 4):
Sodium acetate
\( (Q=4.5; Q_{human\ tox.}(50.0\%)=5; Q_{ecotox.}(50.0\%)=4) \)
Excess: 0.11 --> 0.52

step 2 (Route A 2):
Nitric acid 65%
  \( Q = 5.0; \text{Q_human tox.}(50.0\%) = 6; \text{Q_ecotox.}(50.0\%) = 4 \)
  Excess: 1.28 \( \rightarrow \) 6.41

step 1 (Route A 1):
  Thionyl chloride
  \( Q = 5.0; \text{Q_human tox.}(50.0\%) = 6; \text{Q_ecotox.}(50.0\%) = 4 \)
  Excess: 0.11 \( \rightarrow \) 0.54

  Pyridine
  \( Q = 7.3; \text{Q_human tox.}(33.3\%) = 5; \text{Q_chron. tox.}(33.3\%) = 10; \text{Q_ecotox.}(33.3\%) = 7 \)
  Excess: 0.02 \( \rightarrow \) 0.14

EI_out/Route A:
By-products (47.9(6.88\%) of 696.65):
step 6 (Route A):
  Unknown by-products:
    \( Q = 2.2 \text{ Calculated from the weightings of the substrates} \)
    Loss: 0.03 \( \rightarrow \) 0.07

step 5 (Route A 5):
  Unknown by-products:
    \( Q = 2.3 \text{ Calculated from the weightings of the substrates} \)
    Loss: 0.83 \( \rightarrow \) 1.90

further syntheses appendant to step 5:
  appendant to Oxime (Substrate):
    Unknown by-products:
      \( Q = 5.0 \text{ Calculated from the weightings of the substrates} \)
      Loss: 0.13 \( \rightarrow \) 0.64

step 4 (Route A 4):
  Unknown by-products:
    \( Q = 6.4 \text{ Calculated from the weightings of the substrates} \)
    Loss: 0.13 \( \rightarrow \) 0.82

step 3 (Route A 3):
  Unknown by-products:
    \( Q = 10.0 \text{ Calculated from the weightings of the substrates} \)
    Loss: 0.13 \( \rightarrow \) 1.29
step 2 (Route A 2):
Unknown by-products:
(Q=7.2 Calculated from the weightings of the substrates)
Loss: 1.16 --> 8.29

step 1 (Route A 1):
Pentaerythrityl tetrachloride
(Q=8.0; Q_human tox.(33.3%)=4; Q_chron. tox.(33.3%)=10; Q_ecotox.(33.3%)=10)
Loss: 0.78 --> 6.27

Unknown by-products:
(Q=5.8 Calculated from the weightings of the substrates)
Loss: 4.97 --> 28.62

EI_out/Route A:
Coupled products (54.7(7.85%) of 696.65):
step 6 (Route A):
Potassium acetate
(Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
Loss: 0.89 --> 2.22

step 5 (Route A 5):
NaCl
(Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
Loss: 0.27 --> 0.67

Water
(Q=1)
Loss: 0.08 --> 0.08

further syntheses appendant to step 5:
appendant to Oxime (Substrate):
Carbon dioxide
(Q=1.0; Q_human tox.(100.0%)=1)
Loss: 0.22 --> 0.22

Sodium chloride
(Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
Loss: 0.59 --> 1.48
Water
(Q=1)
Loss: 0.27 --> 0.27

step 4 (Route A 4):
NaCl
(Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
Loss: 0.79 --> 1.98

step 3 (Route A 3):
CO2
(Q=1.0; Q_human tox.(100.0%)=1)
Loss: 0.32 --> 0.32

Hydrogen chloride
(Q=5.0; Q_human tox.(50.0%)=6; Q_ecotox.(50.0%)=4)
Loss: 0.26 --> 1.31

step 2 (Route A 2):
NOx
(Q=6.3; Q_human tox.(33.3%)=5; Q_chron. tox.(33.3%)=10; Q_ecotox.(33.3%)=4)
Loss: 1.44 --> 9.13

Water
(Q=1)
Loss: 0.42 --> 0.42

step 1 (Route A 1):
Pyridine
(Q=7.3; Q_human tox.(33.3%)=5; Q_chron. tox.(33.3%)=10; Q_ecotox.(33.3%)=7)
Loss: 2.48 --> 18.17

Sulfur dioxide
(Q=6.3; Q_human tox.(33.3%)=5; Q_chron. tox.(33.3%)=10; Q_ecotox.(33.3%)=4)
Loss: 2.01 --> 12.71

Hydrogen chloride
(Q=5.0; Q_human tox.(50.0%)=6; Q_ecotox.(50.0%)=4)
Loss: 1.14 --> 5.71
Environmental Impact of Feedstock (EI_in) of Route A: 248.49 PEI units/kg product

According to synthetic step:

- step 6: (32.19 (10.79%) of 298.49)
- step 5: (126.33 (42.32%) of 298.49)
- step 4: (7.73 (2.59%) of 298.49)
- step 3: less than 0.1%
- step 2: (78.53 (26.31%) of 298.49)
- step 1: (53.71 (17.99%) of 298.49)

According to substance category:

- Sewage/Water: (76.07 (25.49%) of 298.49)
- Auxiliaries (isolation): (102.31 (34.28%) of 298.49)
- Solvents: (57.39 (19.23%) of 298.49)
- Substrates: (61.83 (20.72%) of 298.49)

Route A/EI_in: Sewage/Water: (76.07 (25.49%) of 298.49):

step 6 (Route A): 
- out of solvent EtOH
  - Water: (Q=1.0; Q_claiming of ressources(100.0%)=1)
    - Mass: 2.42 --> 2.42

- out of auxiliary material Hydrochloric acid (37%aq)
  - Water: (Q=1.0; Q_claiming of ressources(100.0%)=1)
    - Mass: 0.61 --> 0.61

step 5 (Route A 5):
- out of substrate NaOCl 10%
  - Water: (Q=1.0; Q_claiming of ressources(100.0%)=1)
    - Mass: 18.29 --> 18.29

- out of auxiliary material NaCl; Sodium chloride (aq, conc.)
  - Water: (Q=1.0; Q_claiming of ressources(100.0%)=1)
    - Mass: 6.10 --> 6.10

further syntheses appendant to step 5:
appendant to Oxime (Substrate):
  out of auxiliary material Washing water (as Water separately)
  Water
    (Q=1.0; Q_claiming of ressources(100.0%)=1)
    Mass: 5.35 --> 5.35

step 2 (Route A 2):
  out of substrate Nitric acid 65%
  Water
    (Q=1.0; Q_claiming of ressources(100.0%)=1)
    Mass: 2.11 --> 2.11

  out of auxiliary material Washing water (as Water separately)
  Water
    (Q=1.0; Q_claiming of ressources(100.0%)=1)
    Mass: 12.12 --> 12.12

  out of auxiliary material NaOH 1M
  Water
    (Q=1.0; Q_claiming of ressources(100.0%)=1)
    Mass: 16.00 --> 16.00

  out of auxiliary material Hydrochloric acid (37%aq)
  Water
    (Q=1.0; Q_claiming of ressources(100.0%)=1)
    Mass: 1.14 --> 1.14

step 1 (Route A 1):
  out of auxiliary material Washing water (as Water separately)
  Water
    (Q=1.0; Q_claiming of ressources(100.0%)=1)
    Mass: 11.96 --> 11.96

Route A/EI_in:
Auxiliaries (isolation)( 102.31(34.28%) of 298.49 ):
step 6 (Route A):
  Hydrochloric acid (37%aq)
    (Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
    Mass: 0.36 --> 0.72

Dichloromethane
Mass:                          11.49 -->  22.98         Recoverable thereof:            9.19 -->  18.38

step 5 (Route A 5):
Dichloromethane
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Mass:                            17.95 -->    35.89         Recoverable thereof:             14.36 -->    28.71
NaCl; Sodium chloride (aq, conc.)
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass:                             2.03 -->     2.03
Magnesium sulfate
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Mass:                             0.68 -->     1.35

Further syntheses appendant to step 5:
appendant to Oxime (Substrate):
Washing water (as Water separately)
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass:                             0.00 -->     0.00

step 2 (Route A 2):
Washing water (as Water separately)
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass:                             0.00 -->     0.00
NaOH 1M
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Mass:                             0.67 -->     1.33
Hydrochloric acid (37%aq)
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Mass:                             0.67 -->     1.33
Dichloromethane
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Magnesium sulfate
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Mass: 0.27 --> 0.55

step 1 (Route A 1):
Washing water (as Water separately)
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass: 0.00 --> 0.00

Route A/EI_in:
Solvents( 57.39(19.23%) of 298.49 ):
step 6 (Route A):
Water
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass: 2.31 --> 2.31

EtOH
(Q=1.5; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=2)
Mass: 1.21 --> 1.81
Recoverable thereof: 0.97 --> 1.45

step 5 (Route A 5):
Dichloromethane
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Mass: 20.19 --> 40.38
Recoverable thereof: 16.15 --> 32.30

Further syntheses appendant to step 5:
appendant to Oxime (Substrate):
Ethanol
(Q=1.5; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=2)
Mass: 1.87 --> 2.80

Water
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass: 3.72 --> 3.72

step 4 (Route A 4):
Acetonitrile
(Q=3.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=5)
Route A/EI_in:
Substrates (61.83(20.72%) of 298.49):
step 6 (Route A):
  Diacetoxyisoxazoline imported from Route A
  The substrate is imported. Appropriate quantities are attributed
to the precedent syntheses: see there.

  Potassium hydroxide 85%
  \(Q=2.0; \ Q_{claiming \ of \ ressources}(50.0%)=1; \ Q_{risk}(50.0%)=3\)
  Mass: \[0.57 \rightarrow 1.14\]

step 5 (Route A 5):
  Diacetoxyisobutene imported from Route A
  The substrate is imported. Appropriate quantities are attributed
to the precedent syntheses: see there.

  Oxime imported from Oxime
  The substrate is imported. Appropriate quantities are attributed
to the precedent syntheses: see there.

  NaOCl 10%
  \(Q=2.0; \ Q_{claiming \ of \ ressources}(50.0%)=1; \ Q_{risk}(50.0%)=3\)
  Mass: \[2.03 \rightarrow 4.06\]

further syntheses appendant to step 5:
  appendant to Oxime (Substrate):
    Phenylacetaldehyde
    \(Q=2.0; \ Q_{claiming \ of \ ressources}(50.0%)=2; \ Q_{risk}(50.0%)=2\)
    Mass: \[1.28 \rightarrow 2.57\]

    Hydroxylamine Hydrochloride
    \(Q=3.5; \ Q_{claiming \ of \ ressources}(50.0%)=1; \ Q_{risk}(50.0%)=6\)
    Mass: \[0.89 \rightarrow 3.12\]

    Sodium carbonate
    \(Q=1.0; \ Q_{claiming \ of \ ressources}(50.0%)=1; \ Q_{risk}(50.0%)=1\)
    Mass: \[0.68 \rightarrow 0.68\]
step 4 (Route A 4):
3-Chloro-2-chloromethyl-1-propene imported from Route A 3
The substrate is imported. Appropriate quantities are attributed to the precedent syntheses: see there.

Sodium acetate
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass: 1.30 --> 1.30

step 3 (Route A 3):
Trichloroacid imported from Route A 2
The substrate is imported. Appropriate quantities are attributed to the precedent syntheses: see there.

step 2 (Route A 2):
Trichloro imported from Route A 1
The substrate is imported. Appropriate quantities are attributed to the precedent syntheses: see there.

Nitric acid 65%
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Mass: 3.91 --> 7.83

step 1 (Route A 1):
Pentaerythritol
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass: 2.49 --> 2.49

Thionyl chloride
(Q=4.5; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=8)
Mass: 6.65 --> 29.91

Pyridine
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Mass: 4.37 --> 8.73
Route B. Alternative route (this paper)

Atom Selectivity (AS) of Route B

Route B:

- step 3 (Route B):
  AS (of the following synthesis): 56.5%, AS (of the synthesis sequence): 24.5%
  1 Isoxazoline carbethoxy + 1 NaBH4 + 1 Hydrochloric acid (37%aq) + 3 Water ---> 1 Isoxazoline diol + 1 Boric acid + 1 NaCl + 2 Hydrogen + 1 EtOH

- step 2 (Route B 2):
  AS (of the following synthesis): 77.5%, AS (of the synthesis sequence): 33.9%
  1 Hydroxymethylacrylate + 1 Oxime + 1 NaOCl 10% ---> 1 Isoxazoline carbethoxy + 1 NaCl + 1 Water

  further syntheses appendant to step 2:
  appendant to Oxime (Substrate):
  AS (of the following synthesis): 55.7%, AS (of the synthesis sequence): 55.7%
  2 Phenylacetaldehyde + 2 Hydroxylamine Hydrochloride + 1 Sodium carbonate ---> 2 Oxime + 1 Carbon dioxide + 2 Sodium chloride + 3 Water

- step 1 (Route B 1):
  AS (of the following synthesis): 28.4%, AS (of the synthesis sequence): 28.4%
  1 (EtO)2POCH2COOEt + 2 (CH2O)n + 1 K2CO3 + 2 Water ---> 1 Hydroxymethylacrylate + 1 K2CO3 + 1 KH2PO4 + 2 EtOH
E-factor of Route B: 101.98 kg waste/kg product

According to synthetic step:
step 3    (15.90 (15.59%) of 101.98)
step 2    (59.18 (58.03%) of 101.98)
step 1    (26.90 (26.38%) of 101.98)

According to substance category:
Sewage/Water   (25.48 (24.98%) of 101.98)
Auxiliaries (isolation) (41.49 (40.68%) of 101.98)
Solvents   (26.29 (25.77%) of 101.98)
Substrates   ( 3.09 ( 3.03%) of 101.98)
By-products   ( 1.38 ( 1.35%) of 101.98)
Coupled products ( 4.23 ( 4.15%) of 101.98)

Route B/E:
Sewage/Water( 25.48(24.98%) of 101.98 ):
step 3 (Route B):
  out of substrate Hydrochloric acid (37%aq)
    Water
    Mass: 0.14
  out of solvent EtOH
    Water
    Mass: 6.52

step 2 (Route B 2):
  out of substrate NaOCl 10%
    Water
    Mass: 8.76
  out of auxiliary material Washing water (as Water separately)
    Water
    Mass: 4.54
  out of auxiliary material NaCl; Sodium chloride (aq, conc.)
    Water
    Mass: 0.82

further syntheses appendant to step 2:
  appendant to Oxime (Substrate):
out of auxiliary material Washing water (as Water separately)
Water
Mass: 3.72

step 1 (Route B 1):
out of catalyst H3PO4 1N
Water
Mass: 0.22

out of auxiliary material NaCl; Sodium chloride (aq, conc.)
Water
Mass: 0.77

Route B/E:
Auxiliaries (isolation) (41.49(40.68%) of 101.98):
step 3 (Route B):
Dichloromethane
Loss: 4.51
Recoverable thereof: 3.61

step 2 (Route B 2):
Dichloromethane
Loss: 22.55
Recoverable thereof: 18.04

Washing water (as Water separately)
Loss: 0.00

NaCl; Sodium chloride (aq, conc.)
Loss: 0.27

Magnesium sulfate
Loss: 0.41

further syntheses appendant to step 2:
appendant to Oxime (Substrate):
Washing water (as Water separately)
Loss: 0.00

step 1 (Route B 1):
Et2O
<table>
<thead>
<tr>
<th>Loss:</th>
<th>13.06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recoverable thereof:</td>
<td>10.45</td>
</tr>
</tbody>
</table>

NaCl; Sodium chloride (aq, conc.)
| Loss: | 0.26 |

Na2SO4
| Loss: | 0.43 |

**Route B/E:**

**Solvents( 26.29(25.77%) of 101.98 ):**

step 3 (Route B):
- EtOH
  | Loss: | 3.26 |
  | Recoverable thereof: | 2.61 |

step 2 (Route B 2):
- Dichloromethane
  | Loss: | 12.03 |
  | Recoverable thereof: | 9.62 |

*Further syntheses appendant to step 2:*
  - appendant to Oxime (Substrate):
    - Ethanol
      | Loss: | 1.30 |
    - Water
      | Loss: | 2.58 |

step 1 (Route B 1):
- Water
  | Loss: | 7.12 |

**Route B/E:**

**Substrates( 3.09(3.03%) of 101.98 ):**

step 3 (Route B):
- NaBH4
  | Excess: | 0.00 |
  | (*Utilized mass (pure): | 0.23*) |
  | (*Converted mass: | 0.23*) |
Hydrochloric acid (37%aq)
  Excess: 0.00
  (*Utilized mass (pure): 0.23*)
  (*Converted mass: 0.22*)

Water
  Excess: 0.03
  (*Utilized mass (pure): 0.37*)
  (*Converted mass: 0.33*)

step 2 (Route B 2):
  Oxime
    Excess: 0.03
    (*Utilized mass (pure): 0.95*)
    (*Converted mass: 0.92*)

NaOCl 10%
  Excess: 0.47
  (*Utilized mass (pure): 0.97*)
  (*Converted mass: 0.51*)

further syntheses appendant to step 2:
  appendant to Oxime (Substrate):
    Hydroxylamine Hydrochloride
      Excess: 0.10
      (*Utilized mass (pure): 0.62*)
      (*Converted mass: 0.52*)

Sodium carbonate
  Excess: 0.08
  (*Utilized mass (pure): 0.47*)
  (*Converted mass: 0.39*)

step 1 (Route B 1):
  (CH2O)n
    Excess: 2.27
    (*Utilized mass (pure): 2.73*)
    (*Converted mass: 0.46*)

K2CO3
  Excess: 0.10
(*Utilized mass (pure): 1.17*)
(*Utilized mass (pure): 0.28*)

Water
Excess: 0.01

Route B/E:
By-products (1.38(1.35%) of 101.98):
step 3 (Route B):
   Unknown by-products:
      Loss: 0.64

step 2 (Route B 2):
   Unknown by-products:
      Loss: 0.22

   Further syntheses appendant to step 2:
      appendant to Oxime (Substrate):
         Unknown by-products:
            Loss: 0.09

step 1 (Route B 1):
   Unknown by-products:
      Loss: 0.43

Route B/E:
Coupled products (4.23(4.15%) of 101.98):
step 3 (Route B):
   Boric acid
      Loss: 0.28
      (*Total mass: 0.28*)

   NaCl
      Loss: 0.26
      (*Total mass: 0.26*)

   Hydrogen
      Loss: 0.02
      (*Total mass: 0.02*)
EtOH
Loss: 0.21
(*Total mass: 0.21*)

step 2 (Route B 2):
NaCl
Loss: 0.36
(*Total mass: 0.36*)
Water
Loss: 0.11
(*Total mass: 0.11*)

further syntheses appendant to step 2:
appendant to Oxime (Substrate):
Carbon dioxide
Loss: 0.16
(*Total mass: 0.16*)
Sodium chloride
Loss: 0.41
(*Total mass: 0.41*)
Water
Loss: 0.19
(*Total mass: 0.19*)

step 1 (Route B 1):
KHCO3
Loss: 0.68
(*Total mass: 0.68*)
KH2PO4
Loss: 0.93
(*Total mass: 0.93*)
EtOH
Loss: 0.63
(*Total mass: 0.63*)
Environmental Impact of Waste (EI_out) of Route B: 401.63 PEI units/kg product

According to synthetic step:
step 3  (49.88 (12.42%) of 401.63)
step 2  (264.77 (65.92%) of 401.63)
step 1  (86.98 (21.66%) of 401.63)

According to substance category:
Sewage/Water  (25.48 (6.34%) of 401.63)
Auxiliaries (isolation)  (230.79 (57.46%) of 401.63)
Solvents  (103.56 (25.78%) of 401.63)
Substrates  (21.07 (5.25%) of 401.63)
By By-products  (5.35 (1.33%) of 401.63)
Coupled products  (15.23 (3.79%) of 401.63)

Route B/EI_out:
Sewage/Water( 25.48(6.34%) of 401.63 ):
step 3 (Route B):
  out of substrate Hydrochloric acid (37%aq)
    Water
      (Q=1)
      Mass:  0.14 --> 0.14
  out of solvent EtOH
    Water
      (Q=1)
      Mass:  6.52 --> 6.52

step 2 (Route B 2):
  out of substrate NaOCl 10%
    Water
      (Q=1)
      Mass:  8.76 --> 8.76
  out of auxiliary material Washing water (as Water separately)
    Water
      (Q=1)
      Mass:  4.54 --> 4.54
  out of auxiliary material NaCl; Sodium chloride (aq, conc.)
    Water
(Q=1)
Mass:                      0.82 -->  0.82

Further syntheses appendant to step 2:
appendant to Oxime (Substrate):
out of auxiliary material Washing water (as Water separately)
Water
(Q=1)
Mass:                      3.72 -->  3.72

Step 1 (Route B 1):
out of catalyst H3PO4 1N
Water
(Q=1)
Mass:                      0.22 -->  0.22

out of auxiliary material NaCl; Sodium chloride (aq, conc.)
Water
(Q=1)
Mass:                      0.77 -->  0.77

Route B/El_out:
Auxiliaries (isolation) (230.79(57.46%) of 401.63):
Step 3 (Route B):
Dichloromethane
(Q=6.7; Q_human tox.(33.3%)=3; Q_chron. tox.(33.3%)=10;
Q_ecotox.(33.3%)=7)
Loss:                      4.51 -->  30.07
Recoverable thereof:       3.61 -->  24.05

Step 2 (Route B 2):
Dichloromethane
(Q=6.7; Q_human tox.(33.3%)=3; Q_chron. tox.(33.3%)=10;
Q_ecotox.(33.3%)=7)
Loss:                      22.55 -->  150.33
Recoverable thereof:       18.04 -->  120.26

Washing water (as Water separately)
(Q=1)
Loss:                      0.00 -->  0.00
NaCl; Sodium chloride (aq, conc.)
(Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
Loss: 0.27 --> 0.68

Magnesium sulfate
(Q=3.0; Q_human tox.(50.0%)=2; Q_ecotox.(50.0%)=4)
Loss: 0.41 --> 1.23

Further syntheses appendant to step 2:
appendant to Oxime (Substrate):
Washing water (as Water separately)
(Q=1)
Loss: 0.00 --> 0.00

Step 1 (Route B 1):
Et20
(Q=3.5; Q_human tox.(50.0%)=3; Q_ecotox.(50.0%)=4)
Loss: 13.06 --> 45.72
Recoverable thereof: 10.45 --> 36.57

NaCl; Sodium chloride (aq, conc.)
(Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
Loss: 0.26 --> 0.64

Na2SO4
(Q=5.0; Q_human tox.(50.0%)=6; Q_ecotox.(50.0%)=4)
Loss: 0.43 --> 2.13

Route B/EI_out:
Solvents (103.56(25.78%) of 401.63):
Step 3 (Route B):
EtOH
(Q=3.0; Q_human tox.(50.0%)=2; Q_ecotox.(50.0%)=4)
Loss: 3.26 --> 9.79
Recoverable thereof: 2.61 --> 7.83

Step 2 (Route B 2):
Dichloromethane
(Q=6.7; Q_human tox.(33.3%)=3; Q_chron. tox.(33.3%)=10;
Q_ecotox.(33.3%)=7
Loss: 12.03 --> 80.18
Recoverable thereof: 9.62 --> 64.14

Further syntheses appendant to step 2:
appendant to Oxime (Substrate):
   Ethanol
   (Q=3.0; Q_human tox.(50.0%)=2; Q_ecotox.(50.0%)=4)
   Loss: 1.30 --> 3.89

   Water
   (Q=1)
   Loss: 2.58 --> 2.58

step 1 (Route B 1):
   Water
   (Q=1)
   Loss: 7.12 --> 7.12

Route B/EI_out:
Substrates (21.07(5.25%) of 401.63):
step 3 (Route B):
   NaBH4
   (Q=7.5; Q_human tox.(50.0%)=8; Q_ecotox.(50.0%)=7)
   Excess: 0.00 --> 0.00

   Hydrochloric acid (37%aq)
   (Q=5.0; Q_human tox.(50.0%)=6; Q_ecotox.(50.0%)=4)
   Excess: 0.00 --> 0.00

   Water
   (Q=1)
   Excess: 0.03 --> 0.03

step 2 (Route B 2):
   Oxime
   (Q=1)
   Excess: 0.03 --> 0.03

NaOCl 10%
(Q=7.7; Q_human tox.(33.3%)=6; Q_chron. tox.(33.3%)=10; Q_ecotox.(33.3%)=7)
Excess: 0.47 --> 3.58

further syntheses appendant to step 2:
appendant to Oxime (Substrate):
Hydroxylamine Hydrochloride
(Q=7.0; Q_human tox.(50.0%)=4; Q_ecotox.(50.0%)=10)
Excess: 0.10 --> 0.73

Sodium carbonate
(Q=4.5; Q_human tox.(50.0%)=5; Q_ecotox.(50.0%)=4)
Excess: 0.08 --> 0.36

step 1 (Route B 1):
(CH2O)n
(Q=7.0; Q_human tox.(33.3%)=4; Q_chron. tox.(33.3%)=10; Q_ecotox.(33.3%)=7)
Excess: 2.27 --> 15.88

K2CO3
(Q=4.5; Q_human tox.(50.0%)=5; Q_ecotox.(50.0%)=4)
Excess: 0.10 --> 0.45

Water
(Q=1)

Route B/EI_out:
By-products( 5.35(1.33%) of 401.63 ):
step 3 (Route B):
Unknown by-products:
(Q=2.0 Calculated from the weightings of the substrates)
Loss: 0.64 --> 1.29

step 2 (Route B 2):
Unknown by-products:
(Q=2.5 Calculated from the weightings of the substrates)
Loss: 0.22 --> 0.53

further syntheses appendant to step 2:
appendant to Oxime (Substrate):
  Unknown by-products:
    (Q=5.0 Calculated from the weightings of the substrates)
    Loss: 0.09 --> 0.45

step 1 (Route B 1):
  Unknown by-products:
    (Q=7.2 Calculated from the weightings of the substrates)
    Loss: 0.43 --> 3.08

Route B/EI_out:
Coupled products (15.23(3.79%) of 401.63):
step 3 (Route B):
  Boric acid
    (Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
    Loss: 0.28 --> 0.70

  NaCl
    (Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
    Loss: 0.26 --> 0.66

  Hydrogen
    (Q=1)
    Loss: 0.02 --> 0.02

  EtOH
    (Q=3.0; Q_human tox.(50.0%)=2; Q_ecotox.(50.0%)=4)
    Loss: 0.21 --> 0.62

step 2 (Route B 2):
  NaCl
    (Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
    Loss: 0.36 --> 0.90

  Water
    (Q=1)
    Loss: 0.11 --> 0.11

further syntheses appendant to step 2:
  appendant to Oxime (Substrate):
Carbon dioxide
(Q=1.0; Q_human tox.(100.0%)=1)
Loss: 0.16 --> 0.16

Sodium chloride
(Q=2.5; Q_human tox.(50.0%)=1; Q_ecotox.(50.0%)=4)
Loss: 0.41 --> 1.03

Water
(Q=1)
Loss: 0.19 --> 0.19

step 1 (Route B 1):

KHCO3
(Q=5.0; Q_human tox.(50.0%)=6; Q_ecotox.(50.0%)=4)
Loss: 0.68 --> 3.40

KH2PO4
(Q=6.0; Q_human tox.(50.0%)=5; Q_ecotox.(50.0%)=7)
Loss: 0.93 --> 5.55

EtOH
(Q=3.0; Q_human tox.(50.0%)=2; Q_ecotox.(50.0%)=4)
Loss: 0.63 --> 1.88
Environmental Impact of Feedstock (EI_in) Route B: 196.38 PEI units/kg product

According to synthetic step:
- step 3  \( (22.35 \ (11.38\%) \ of \ 196.38) \)
- step 2  \( (98.97 \ (50.39\%) \ of \ 196.38) \)
- step 1  \( (75.07 \ (38.23\%) \ of \ 196.38) \)

Main contributions:
- Sewage/Water  \( (25.48 \ (12.97\%) \ of \ 196.38) \)
- Auxiliaries (isolation)  \( (101.61 \ (51.74\%) \ of \ 196.38) \)
- Solvents  \( (40.59 \ (20.67\%) \ of \ 196.38) \)
- Substrates  \( (28.65 \ (14.59\%) \ of \ 196.38) \)

Route B/EI_in:

**Sewage/Water(25.48(12.97%) of 196.38):**

- step 3 (Route B):
  - out of substrate Hydrochloric acid (37%aq)
    - Water  \( (Q=1.0; \ Q_{claiming \ of \ ressources}(100.0\%)=1) \)
      - Mass: 0.14 --> 0.14
  - out of solvent EtOH
    - Water  \( (Q=1.0; \ Q_{claiming \ of \ ressources}(100.0\%)=1) \)
      - Mass: 6.52 --> 6.52

- step 2 (Route B 2):
  - out of substrate NaOCl 10%
    - Water  \( (Q=1.0; \ Q_{claiming \ of \ ressources}(100.0\%)=1) \)
      - Mass: 8.76 --> 8.76
  - out of auxiliary material Washing water (as Water separately)
    - Water  \( (Q=1.0; \ Q_{claiming \ of \ ressources}(100.0\%)=1) \)
      - Mass: 4.54 --> 4.54
  - out of auxiliary material NaCl; Sodium chloride (aq, conc.)
    - Water  \( (Q=1.0; \ Q_{claiming \ of \ ressources}(100.0\%)=1) \)
      - Mass: 0.82 --> 0.82
further syntheses appendant to step 2:
  appendant to Oxime (Substrate):
    out of auxiliary material Washing water (as Water separately)
      Water
        (Q=1.0; Q_claiming of ressources(100.0%)=1)
        Mass: 3.72 --> 3.72
  step 1 (Route B 1):
    out of catalyst H3PO4 1N
      Water
        (Q=1.0; Q_claiming of ressources(100.0%)=1)
        Mass: 0.22 --> 0.22
    out of auxiliary material NaCl; Sodium chloride (aq, conc.)
      Water
        (Q=1.0; Q_claiming of ressources(100.0%)=1)
        Mass: 0.77 --> 0.77

Route B/EI_in:
Auxiliaries (isolation)( 101.61(51.74%) of 196.38 ):
  step 3 (Route B):
    Dichloromethane
      (Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
      Mass: 4.51 --> 9.02
      Recoverable thereof: 3.61 --> 7.22
  step 2 (Route B 2):
    Dichloromethane
      (Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
      Mass: 22.55 --> 45.10
      Recoverable thereof: 18.04 --> 36.08

Washing water (as Water separately)
  (Q=1.0; Q_claiming of ressources(100.0%)=1)
  Mass: 0.00 --> 0.00

NaCl; Sodium chloride (aq, conc.)
  (Q=1.0; Q_claiming of ressources(100.0%)=1)
  Mass: 0.27 --> 0.27
Magnesium sulfate  
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)  
Mass: 0.41 --> 0.82  

further syntheses appendant to step 2:  
appendant to Oxime (Substrate):  
Washing water (as Water separately)  
(Q=1.0; Q_claiming of ressources(100.0%)=1)  
Mass: 0.00 --> 0.00  

step 1 (Route B 1):  
Et2O  
(Q=3.5; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=6)  
Mass: 13.06 --> 45.72  
Recoverable thereof: 10.45 --> 36.57  

NaCl; Sodium chloride (aq, conc.)  
(Q=1.0; Q_claiming of ressources(100.0%)=1)  
Mass: 0.26 --> 0.26  

Na2SO4  
(Q=1.0; Q_claiming of ressources(100.0%)=1)  
Mass: 0.43 --> 0.43  

Route B/EI_in:  
Solvents (40.59(20.67%) of 196.38):  
step 3 (Route B):  
EtOH  
(Q=1.5; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=2)  
Mass: 3.26 --> 4.89  
Recoverable thereof: 2.61 --> 3.91  

step 2 (Route B 2):  
Dichloromethane  
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)  
Mass: 12.03 --> 24.05  

further syntheses appendant to step 2:  
appendant to Oxime (Substrate):  
Ethanol
(Q=1.5; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=2)
Mass: 1.30 --> 1.95

Water
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass: 2.58 --> 2.58

step 1 (Route B 1):
Water
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass: 7.12 --> 7.12

Route B/El_in:
Substrates( 28.65(14.59%) of 196.38 ):
step 3 (Route B):
  Isoxazoline carbethoxy imported from Route B 2
    The substrate is imported. Appropriate quantities are attributed to the precedent syntheses: see there.
    NaBH4
(Q=4.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=7)
Mass: 0.23 --> 0.93

    Hydrochloric acid (37%aq)
(Q=2.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=3)
Mass: 0.23 --> 0.45

    Water
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass: 0.37 --> 0.37

step 2 (Route B 2):
Hydroxymethylacrylate imported from Route B 1
    The substrate is imported. Appropriate quantities are attributed to the precedent syntheses: see there.
    Oxime imported from Oxime
    The substrate is imported. Appropriate quantities are attributed to the precedent syntheses: see there.
    NaOCl 10%
Further syntheses appendant to step 2:

Appendant to Oxime (Substrate):

Phenylacetaldehyde
(Q=2.0; Q_claiming of ressources(50.0%)=2; Q_risk(50.0%)=2)
Mass: 0.89 --> 1.78

Hydroxylamine Hydrochloride
(Q=3.5; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=6)
Mass: 0.62 --> 2.17

Sodium carbonate
(Q=1.0; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=1)
Mass: 0.47 --> 0.47

Step 1 (Route B 1):

(EtO)2POCH2COOEt
(Q=2.0; Q_claiming of ressources(100.0%)=2)
Mass: 1.73 --> 3.46

(CH2O)n
(Q=5.5; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=10)
Mass: 2.73 --> 15.03

K2CO3
(Q=1.5; Q_claiming of ressources(50.0%)=1; Q_risk(50.0%)=2)
Mass: 1.17 --> 1.75

Water
(Q=1.0; Q_claiming of ressources(100.0%)=1)
Mass: 0.28 --> 0.28
Comparisons of three indexes (E, EI_out, and EI_in) for both routes.
According to substance category
Comparisons of three indexes (E, EI_out, and EI_in) for both routes.
According to synthetic step.