

CLAIMS*We Claim:*

1. A process for producing an alkylated aromatic product which comprises ethylbenzene or cumene in a first reaction zone, comprising the steps of:
 - (a) feeding a predominantly liquid phase first feedstock which comprises benzene and an at least partially vapor phase second feedstock which comprises at least one alkene compound selected from the group consisting of ethylene and propylene and, optionally, at least one alkane compound selected from the group consisting of methane, ethane, and propane, to said first reaction zone;
 - (b) operating said first reaction zone under first temperature and pressure conditions sufficient to ensure that the mixture of said first feedstock and said second feedstock is in mixed phase in at least a portion of said reaction zone;
 - (c) contacting said feedstock mixture and a first alkylation catalyst in said first reaction zone, to produce a first effluent which comprises said alkylated aromatic product and polyalkylated aromatic compounds, wherein said first effluent exits said reaction zone in predominantly liquid phase; and
 - (d) maintaining said first reaction zone under second temperature and pressure conditions sufficient to ensure a phase change from mixed phase to liquid phase in at least a portion of said first reaction zone.
 2. The process of claim 1 wherein said first alkylation catalyst comprises a molecular sieve selected from the group consisting of MCM-22, MCM-36, MCM-49 and MCM-56, beta zeolite, faujasite, mordenite, PSH-3, SSZ-25, ERB-1, ITQ-1, ITQ-2, zeolite Y, Ultrastable Y (USY), Dealuminized Y (DealY), rare earth exchanged Y (REY), ZSM-3, ZSM-4, ZSM-18, ZSM-20, and any combination thereof.
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3. The process of claim 1, wherein said first temperature and pressure conditions include a temperature of 100 to 260°C and a pressure of 689 to 4601 kPa-a (100 to 667 psia).
4. The process of claim 1, wherein said second temperature and pressure conditions include a temperature of 150 to 285°C and a pressure of 689 to 4601 kPa-a (100 to 667 psia).
5. The process of claim 1, wherein said first feedstock has at least 99 wt.% liquid phase.
6. The process of claim 1, wherein said second feedstock comprises at least 50 mol.% alkene.
7. The process of claim 1, wherein said second feedstock comprises at least 90 mol.% alkene.
8. The process of any preceding claim, further comprising the step of:
 - (c) contacting said polyalkylated aromatic compounds and a third feedstock which comprises alkylatable aromatic compound(s) in the presence of a transalkylation catalyst in a transalkylation reaction zone under transalkylation conditions, to produce a second effluent which comprises additional monoalkylated aromatic product.
9. The process of claim 8, further comprising the step of:
 - (d) separating said first and/or second effluents to recover said monoalkylated aromatic product.
10. The process of claim 8, wherein said transalkylation catalyst comprises a molecular sieve selected from the group consisting of MCM-22, MCM-36, MCM-49 and MCM-56, beta zeolite, faujasite, mordenite, PSH-3, SSZ-25, ERB-

1, ITQ-1, ITQ-2, zeolite Y, Ultrastable Y (USY), Dealuminized Y (DealY), rare earth exchanged Y (REY), ZSM-3, ZSM-4, ZSM-18, ZSM-20, and any combination thereof.

11. The process of claim 8, wherein said transalkylation conditions are effective to maintain said second effluent stream substantially in a vapor phase.

12. The process of claim 8, wherein said transalkylation conditions are effective to maintain said second effluent stream substantially in a liquid phase.

13. The process of claim 11, wherein said vapor phase transalkylation conditions include a temperature of 350 to 450°C and a pressure of 696 to 1601 kPa-a (101 to 232 psia), a WHSV based on the weight of said polyalkylated aromatic compounds of about 0.5 to 20 h⁻¹, a mole ratio of said alkylatable aromatic compound to said polyalkylated aromatic compounds of 1:1 to 5:1.

14. The process of claim 12, wherein said liquid phase transalkylation conditions include a temperature of 150 to 260°C and a pressure of 696 to 4137 kPa-a (101 to 600 psia), a WHSV based on the weight of said polyalkylated aromatic compounds of about 0.5 to 100 h⁻¹, a mole ratio of said alkylatable aromatic compound to said polyalkylated aromatic compounds of 1:1 to 10:1.

15. The process of claim 8, further comprising the steps of:

- (d) cooling said first effluent stream to form a cooled first effluent stream;
- (e) feeding at least a portion of said cooled first effluent stream and additional said second feedstock to a second reaction zone of a multistage reactor operated under third temperature and pressure conditions; and
- (f) contacting the mixture of step (d) with a second alkylation catalyst in said second reaction zone to produce a second effluent which comprises additional said monoalkylated aromatic product.

16. The process of claim 15, wherein said third temperature and pressure conditions are effective to maintain said mixture of step (f) in a mixed phase.
17. The process of claim 16, wherein said third temperature and pressure conditions include a temperature of 120 to 285°C and a pressure of 689 to 4601 kPa-a (100 to 667 psia).
18. The process of claim 15, wherein said third temperature and pressure conditions are effective to maintain said mixture of step (d) in a liquid phase.
19. The process of claim 15, wherein said second alkylation catalyst comprise a molecular sieve selected from the group consisting of MCM-22, MCM-36, MCM-49 and MCM-56, beta zeolite, faujasite, mordenite, PSH-3, SSZ-25, ERB-1, ITQ-1, ITQ-2, zeolite Y, Ultrastable Y (USY), Dealuminized Y, rare earth exchanged Y (REY), ZSM-3, ZSM-4, ZSM-18, ZSM-20, and any combination thereof.
20. The process of claim 15, further comprising the step of:
- (g) separating said first and second effluents, to recover said monoalkylated aromatic product.
21. The process of claim 20, further comprising the steps of:
- (h) further separating said first and second effluents, to recover said polyalkylated aromatic compounds as a transalkylation feedstock; and
 - (i) contacting said transalkylation feedstock with a third feedstock which comprises said alkylatable aromatic compounds in the presence of a transalkylation catalyst in a transalkylation reaction zone under transalkylation conditions, to produce a third effluent which comprises additional monoalkylated aromatic product.

22. The process of claim 21, further comprising the step of:
- (j) separating said third effluent, to recover said additional monoalkylated aromatic product.
23. The process of claim 21, wherein said transalkylation catalyst comprises a molecular sieve selected from the group consisting of MCM-22, MCM-36, MCM-49 and MCM-56, beta zeolite, faujasite, mordenite, PSH-3, SSZ-25, ERB-1, ITQ-1, ITQ-2, zeolite Y, Ultrastable Y (USY), Dealuminized Y, rare earth exchanged Y (REY), ZSM-3, ZSM-4, ZSM-18, ZSM-20, and any combination thereof.
24. The process of claim 21, wherein said transalkylation conditions are effective to maintain said third effluent in a predominantly vapor phase.
25. The process of claim 21, wherein said transalkylation conditions are effective to maintain said second effluent in a predominantly liquid phase.
26. The process of claim 21, wherein said transalkylation conditions include a temperature of 350 to 450°C and a pressure of 696 to 1601 kPa-a (101 to 232 psia), a WHSV based on the weight of said polyalkylated aromatic compounds of about 0.5 to 20 h⁻¹, a mole ratio of said alkylatable aromatic compound to said polyalkylated aromatic compounds of 1:1 to 5:1.
27. The process of claim 21, wherein said transalkylation conditions include a temperature of 150 to 260°C and a pressure of 696 to 4137 kPa-a (101 to 600 psia), a WHSV based on the weight of said polyalkylated aromatic compounds of about 0.5 to 100 h⁻¹, a mole ratio of said alkylatable aromatic compound to said polyalkylated aromatic compounds of 1:1 to 10:1.

CLAIMS

1. A process for producing an alkylated aromatic product which comprises ethylbenzene or cumene in a first reaction zone of an alkylation reactor, comprising the steps of:

(a) co-currently feeding a predominantly liquid phase first feedstock which comprises benzene and an at least partially vapor phase second feedstock which comprises at least one alkene compound selected from the group consisting of ethylene and propylene and at least one alkane compound selected from the group consisting of methane, ethane, and propane, to an inlet portion of said first reaction zone, wherein said first reaction zone is operated under conditions sufficient to ensure that the mixture of said first feedstock and said second feedstock is in mixed phase in at least a portion of said reaction zone; and

(b) contacting said feedstock mixture and a first alkylation catalyst which comprises a molecular sieve selected from the group consisting of MCM-22, MCM-36, MCM-49 and MCM-56, beta zeolite, faujasite, mordenite, PSH-3, SSZ-25, ERB-1, ITQ-1, ITQ-2, zeolite Y, Ultrastable Y (USY), Dealuminized Y (DealY), rare earth exchanged Y (REY), ZSM-3, ZSM-4, ZSM-18, ZSM-20, and any combination thereof, in said first reaction zone, to produce a first effluent which comprises said alkylated aromatic product and polyalkylated aromatic compounds, wherein said first effluent exits said reaction zone in at least 95 wt. % liquid phase in the presence of said alkane, downstream of said inlet portion of said reaction zone; and

wherein said conditions of said reaction zone are sufficient to ensure a phase change from mixed phase to liquid phase in at least a portion of said first reaction zone.

2. The process of claim 1, wherein said conditions of said inlet portion of said first reaction zone include a temperature of 120 to 260° C. and a pressure of 689 to 4601 kPa-a (100 to 667 psia), a WHSV based on the weight of alkene of 0.1 to 10 h⁻¹.

3. The process of claim 1, wherein said first feedstock has at least 98 wt. % liquid phase.

4. The process of claim 1, wherein said second feedstock comprises at least 50 mol. % alkene.

5. The process of claim 1, further comprising the step of:

(c) contacting said polyalkylated aromatic compounds and a third feedstock which comprises alkylatable aromatic compound(s) in the presence of a transalkylation catalyst in a transalkylation reaction zone under transalkylation conditions, to produce a transalkylation effluent which comprises additional monoalkylated aromatic product.

6. The process of claim 5, further comprising the step of:
(d) separating said first and/or transalkylation effluents to recover said monoalkylated aromatic product.

7. The process of claim 5, wherein said transalkylation catalyst comprises a molecular sieve selected from the group consisting of MCM-22, MCM-36, MCM-49 and MCM-56, beta zeolite, faujasite, mordenite, PSH-3, SSZ-25, ERB-1, ITQ-1, ITQ-2, zeolite Y, Ultrastable Y (USY), Dealuminized Y (DealY), rare earth exchanged Y (REY), ZSM-3, ZSM-4, ZSM-18, ZSM-20, and any combination thereof.

8. The process of claim 5, wherein said transalkylation conditions are effective to maintain said transalkylation effluent stream substantially in a vapor phase.

9. The process of claim 5, wherein said transalkylation conditions are effective to maintain said transalkylation effluent stream substantially in a liquid phase.

10. The process of claim 8, wherein said vapor phase transalkylation conditions include a temperature of 350 to 450° C. and a pressure of 696 to 1601 kPa-a (101 to 232 psia), a WHSV based on the weight of said polyalkylated aromatic compounds of about 0.5 to 20 h⁻¹, a mole ratio of said alkylatable aromatic compound to said polyalkylated aromatic compounds of 1:1 to 5:1.

11. The process of claim 9, wherein said liquid phase transalkylation conditions include a temperature of 150 to 260° C. and a pressure of 696 to 4137 kPa-a (101 to 600 psia), a WHSV based on the weight of said polyalkylated aromatic compounds of about 0.5 to 100 h⁻¹, a mole ratio of said alkylatable aromatic compound to said polyalkylated aromatic compounds of 1:1 to 10:1.

12. The process of claim 5, further comprising the steps of:
(d) cooling said first effluent stream to form a cooled first effluent stream;

(c) feeding a mixture of at least a portion of said cooled first effluent stream and additional second feedstock to a second reaction zone of said alkylation reactor operated under second conditions; and

(f) contacting the mixture of step (e) with a second alkylation catalyst in said second reaction zone to produce a second effluent which comprises additional monoalkylated aromatic product.

13. The process of claim 12, wherein said second conditions are effective to maintain said mixture of step (e) in a mixed phase.

14. The process of claim 13, wherein said second conditions include a temperature of 120 to 285° C. and a pressure of 689 to 4601 kPa-a (100 to 667 psia), a WHSV based on the weight of alkene of 0.1 to 10 h⁻¹.

15. The process of claim 12, wherein said second conditions are effective to maintain said mixture of step (e) in a liquid phase.

16. The process of claim 12, wherein said second alkylation catalyst comprise a molecular sieve selected from the group consisting of MCM-22, MCM-36, MCM-49 and MCM-56, beta zeolite, faujasite, mordenite, PSH-3, SSZ-25, ERB-1, ITQ-1, ITQ-2, zeolite Y, Ultrastable Y (USY), Dealuminized Y, rare earth exchanged Y (REY), ZSM-3, ZSM-4, ZSM-18, ZSM-20, and any combination thereof.

17. The process of claim 12, further comprising the step of:
(g) separating said first and second effluents, to recover said monoalkylated aromatic product.

18. The process of claim 17, further comprising the steps of:

- (h) further separating from said first and second effluents said polyalkylated aromatic compounds as a transalkylation feedstock; and
- (i) contacting said transalkylation feedstock with said third feedstock which comprises said alkylatable aromatic compounds in the presence of a transalkylation catalyst in a transalkylation reaction zone under transalkylation conditions, to produce a third effluent which comprises additional monoalkylated aromatic product.

19. The process of claim 18, further comprising the step of:
(j) separating said third effluent, to recover said additional monoalkylated aromatic product.

20. The process of claim 18, wherein said transalkylation catalyst comprises a molecular sieve selected from the group consisting of MCM-22, MCM-36, MCM-49 and MCM-56, beta zeolite, faujasite, mordenite, PSH-3, SSZ-25, ERB-1, ITQ-1, ITQ-2, zeolite Y, Ultrastable Y (USY), Dealuminized Y, rare earth exchanged Y (REY), ZSM-3, ZSM-4, ZSM-18, ZSM-20, and any combination thereof.

21. A process for producing a monoalkylated aromatic product as recited in claim 1, where said process is applied to retrofitting an existing ethylbenzene or cumene plant and further comprises the steps of:

- (c) cooling said first effluent stream to form a cooled first effluent stream; and
- (d) feeding a mixture of at least a portion of said cooled first effluent stream and additional second feedstock to a second reaction zone of said multistage reactor operated under second conditions.

22. The process of claim 21, further comprising the step of:
(e) contacting the mixture of step (d) with a transalkylation catalyst in said second reaction zone to produce a transalkylation effluent which comprises additional monoalkylated aromatic product.

23. The process of claim 22, wherein said transalkylation catalyst comprises a molecular sieve selected from the group consisting of beta zeolite, faujasite, mordenite, zeolite Y, Ultrastable Y (USY), Dealuminized Y (DealY), rare earth exchanged Y (REY), and any combination thereof.