into a single column, eliminating at least one major reactor from the conventional configuration for producing ethylbenzene. Cumene and other alkylated benzene species may be produced in a similar manner using the corresponding alcohols.

**[0005]** ~~In one aspect,~~ embodiments disclosed herein relate to a process for the production of alkylbenzene, the process including: feeding a $C_1$ to $C_6$ alcohol and benzene to a catalytic distillation reactor system comprising an upper reaction zone containing an alkylation catalyst and a lower reaction zone containing a transalkylation catalyst, which may be the same or different than the alkylation catalyst; concurrently in the catalytic distillation reactor system: reacting a portion of the alcohol with the benzene within the upper reaction zone to form a reaction mixture containing water, alkylbenzene, dialkyl ether, unreacted alcohol, unreacted benzene, and polyalkylate including dialkylbenzene; reacting a portion of the polyalkylate with benzene in the lower reaction zone to form additional alkylbenzene; and fractionally distilling the reaction mixture; recovering an overheads fraction from the catalytic distillation reactor system comprising benzene, unreacted alcohol, water, and dialkyl ether; recovering a bottoms fraction from the catalytic distillation reactor system comprising benzene, alkylbenzene, and polyalkylate.

**[0006]** In one~~another~~ aspect, embodiments disclosed herein relate to a process for the production of ethylbenzene, the process including: feeding ethanol and benzene to a catalytic distillation reactor system comprising an upper reaction zone containing an alkylation catalyst and a lower reaction zone containing a transalkylation catalyst, which may be the same or different than the alkylation catalyst; concurrently in the catalytic distillation reactor system: reacting a portion of the ethanol with the benzene within the upper reaction zone to form a reaction mixture containing water, ethylbenzene, diethyl ether, unreacted ethanol, unreacted benzene, and polyalkylate including diethylbenzene; reacting a portion of the polyalkylate with benzene in the lower reaction zone to form additional ethylbenzene; and fractionally distilling the reaction mixture; recovering an overheads fraction from the catalytic distillation reactor system comprising benzene, ethanol, water, and diethyl ether; recovering a bottoms fraction from the catalytic distillation reactor system comprising benzene, ethylbenzene, and polyalkylate; condensing and phase separating the overheads fraction to form a first liquid fraction comprising benzene and a second liquid fraction comprising the water, ethanol, and diethyl ether; separating the bottoms fraction from

# CLAIMS

What is claimed:

1.A process for the production of ethylbenzene, the process comprising:

# CLAIMS

1.A process for the production of ethylbenzene, the process comprising:

feeding ethanol and benzene to a catalytic distillation reactor system comprising an upper reaction zone containing an alkylation catalyst and a lower reaction zone containing a transalkylation catalyst, which may be the same or different than the alkylation catalyst;

concurrently in the catalytic distillation reactor system:

reacting a portion of the ethanol with the benzene within the upper reaction zone to form a reaction mixture containing water, ethylbenzene, diethyl ether, unreacted ethanol, unreacted benzene, and polyalkylate including diethylbenzene;

reacting a portion of the polyalkylate with benzene in the lower reaction zone to form additional ethylbenzene; and

fractionally distilling the reaction mixture;

recovering an overheads fraction from the catalytic distillation reactor system comprising benzene, ethanol, water, and diethyl ether;

recovering a bottoms fraction from the catalytic distillation reactor system comprising benzene, ethylbenzene, and polyalkylate;

condensing and phase separating the overheads fraction to form a first liquid fraction comprising benzene and a second liquid fraction comprising the water, ethanol, and diethyl ether;

separating the bottoms fraction from the catalytic distillation reactor system in a first distillation column to recover an overheads fraction comprising benzene and a bottoms fraction comprising ethylbenzene and polyalkylate;

feeding at least a portion of the first liquid fraction to the catalytic distillation reactor system as a reflux;

separating the second liquid fraction in a second distillation column to recover an overheads fraction comprising ethanol and diethyl ether and a bottoms fraction comprising water;

feeding the ethanol feed and at least a portion of the overheads fraction from the second distillation column to the catalytic distillation reactor system intermediate the upper and lower reaction zones.

2.The process of claim 1, further comprising feeding a portion of the first liquid fraction to the catalytic distillation reactor system intermediate the upper and lower reaction zones.

3.The process of claim 1, further comprising separating the bottoms fraction from the first distillation column in a third distillation column to recover an overheads fraction comprising ethylbenzene and a bottoms fraction comprising polyalkylate.

4.The process of claim 1, further comprising separating the bottoms fraction from the first distillation column to recover an overheads fraction comprising ethylbenzene, a sidedraw fraction comprising diethylbenzene, and a bottoms fraction comprising polyalkylate.

5.The process of claim 4, further comprising feeding at least a portion of the sidedraw fraction to the catalytic distillation reactor system intermediate the upper and lower reaction zones.

6.The process of claim 5, wherein the sidedraw fraction further comprises triethylbenzene.

7.The process of claim 4, further comprising using the bottoms fraction comprising polyalkylate as a fuel blend stock.

8.The process of claim 1, wherein the condensing and phase separating the overhead fraction comprises indirect heat exchange of the overheads fraction from the catalytic distillation reactor system with at least one of:

at least a portion of the bottoms fraction comprising water;

at least a portion of the overhead fraction from the second distillation column;

water; and

steam.

9.The process of claim 1, wherein the catalyst in the upper reaction zone is the same as the catalyst in the lower reaction zone.

10.The process of claim 1, further comprising feeding the benzene feed, at least a portion of the first liquid fraction, and at least a portion of the overheads fraction from the first distillation column to the catalytic distillation reactor system as a reflux;

11.The process of claim 1, further comprising:

combining benzene and at least a portion of the overheads fraction from the second distillation column to form a mixture;

phase separating the mixture to recover a third liquid fraction comprising benzene, ethanol, and diethyl ether and a fourth liquid fraction comprising water, ethanol, and diethyl ether;

recycling the fourth liquid fraction to the second distillation column; and

feeding the third liquid fraction and a portion of the first liquid fraction to the catalytic distillation reactor system intermediate the upper and lower reaction zones.

12.The process of claim 11, comprising combining at least a portion of the overheads from the first distillation column, benzene, and at least a portion of the overheads fraction from the second distillation column to form the mixture.

13.A process for the production of cumene, the process comprising:

feeding isopropanol and benzene to a catalytic distillation reactor system comprising an upper reaction zone containing an alkylation catalyst and a lower reaction zone containing a transalkylation catalyst, which may be the same or different than the alkylation catalyst;

concurrently in the catalytic distillation reactor system:

reacting a portion of the isopropanol with the benzene within the upper reaction zone to form a reaction mixture containing water, cumene, diisopropyl ether, unreacted isopropanol, unreacted benzene, and polyalkylate including diisopropylbenzene;

reacting a portion of the polyalkylate with benzene in the lower reaction zone to form additional cumene; and

fractionally distilling the reaction mixture;

recovering an overheads fraction from the catalytic distillation reactor system comprising benzene, isopropanol, water, and diisopropyl ether;

recovering a bottoms fraction from the catalytic distillation reactor system comprising benzene, cumene, and polyalkylate;

condensing and phase separating the overheads fraction to form a first liquid fraction comprising benzene and a second liquid fraction comprising the water, isopropanol, and diisopropyl ether;

separating the bottoms fraction from the catalytic distillation reactor system in a first distillation column to recover an overheads fraction comprising benzene and a bottoms fraction comprising cumene and polyalkylate;

feeding at least a portion of the first liquid fraction to the catalytic distillation reactor system as a reflux;

separating the second liquid fraction in a second distillation column to recover an overheads fraction comprising isopropanol and diisopropyl ether and a bottoms fraction comprising water;

feeding the isopropanol feed and at least a portion of the overheads fraction from the second distillation column to the catalytic distillation reactor system intermediate the upper and lower reaction zones.

14.The process of claim 13, further comprising feeding a portion of the first liquid fraction to the catalytic distillation reactor system intermediate the upper and lower reaction zones.

15.The process of claim 13, further comprising separating the bottoms fraction from the first distillation column in a third distillation column to recover an overheads fraction comprising cumene and a bottoms fraction comprising polyalkylate.

16.The process of claim 13, further comprising separating the bottoms fraction from the first distillation column to recover an overheads fraction comprising cumene, a sidedraw fraction comprising diisopropylbenzene, and a bottoms fraction comprising polyalkylate.

17.The process of claim 16, further comprising feeding at least a portion of the sidedraw fraction to the catalytic distillation reactor system intermediate the upper and lower reaction zones.

18.The process of claim 17, wherein the sidedraw fraction further comprises tricumene.

19.The process of claim 16, further comprising using the bottoms fraction comprising polyalkylate as a fuel blend stock.

20.The process of claim 13, wherein the condensing and phase separating the overhead fraction comprises indirect heat exchange of the overheads fraction from the catalytic distillation reactor system with at least one of:

at least a portion of the bottoms fraction comprising water;

at least a portion of the overhead fraction from the second distillation column;

water; and

steam.

21.The process of claim 13, wherein the catalyst in the upper reaction zone is the same as the catalyst in the lower reaction zone.

22.The process of claim 13, further comprising feeding the benzene feed, at least a portion of the first liquid fraction, and at least a portion of the overheads fraction from the first distillation column to the catalytic distillation reactor system as a reflux;

23.The process of claim 13, further comprising:

combining benzene and at least a portion of the overheads fraction from the second distillation column to form a mixture;

phase separating the mixture to recover a third liquid fraction comprising benzene, isopropanol, and diisopropyl ether and a fourth liquid fraction comprising water, isopropanol, and diisopropyl ether;

recycling the fourth liquid fraction to the second distillation column; and

feeding the third liquid fraction and a portion of the first liquid fraction to the catalytic distillation reactor system intermediate the upper and lower reaction zones.

24.The process of claim 23, comprising combining at least a portion of the overheads from the first distillation column, benzene, and at least a portion of the overheads fraction from the second distillation column to form the mixture.