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SUPPRESSION OF HIGHLY ALKYLATED PHENOLS IN THE CATALYTIC ALKYLATION REACTION OF PHENOL.

BACKGROUND OF THE INVENTION

This invention relates to a method for suppressing the formation of
5 certain alkylated phenols with one or more alkyl groups by transalkylating the alkyl phenols. More particularly, this invention is directed to a method for transalkylating ortho- and para-alkylated phenols with other phenols in the presence of a metal oxide catalyst by recycling these phenols into the feed stream.

10 It is often desirable to dealkylate or transalkylate the alkylated phenols obtained from coal tars of coal liquifaction processes to provide more valuable products, such as phenol. In addition, it is often desirable to dealkylate or transalkylate 2,4,6-trimethylphenol (TMP), a co-product in the synthesis of 2,6-xylenol, to more useful alkylated phenols and phenol. Useful alkylated
15 phenols include p-cresol, o-cresol, 2,6-xylenol, 2,4-dimethylphenol, 2,4,6-trimethylphenol and the like.

A number of methods of dealkylating alkylated phenols are known to the art. These methods include thermal dealkylation, thermal hydrodealkylation, and catalytic hydrodealkylation. Thermal dealkylation

involves exposing alkylated phenols to high temperatures (about 800°C.) to achieve thermal cracking of the alkylated phenol and yield phenol. However, this process is not selective and a substantial amount of dehydroxylation occurs, producing the less valuable benzene and alkyl-substituted benzene species. This process is shown more particularly by Daly in Journal of Catalysis 61, 528 (1980), the contents of which are incorporated herein by reference.

Thermal hydrodealkylation of alkylated phenols involves exposing the alkylated phenols to high temperatures in the presence of steam or hydrogen or both, as is shown by Daly in U.S. Pat. No. 4,230,895. This process also causes a significant amount of dehydroxylation, which is undesirable since dehydroxylation produces less valuable products.

Catalytic hydrodealkylation is typically more selective than the processes described above and causes less dehydroxylation. Daly describes a process in U.S. Pat. No. 4,230,896 wherein alkylated phenols are reacted with steam in the presence of a catalyst comprised of a hydrous carrier, a deactivation suppressor and at least one promoter. Catalysts included within those described by Daly include platinum and palladium on alumina and mixtures of palladium and chromium oxide on alumina. A catalytic hydrodealkylation process which reacts alkylated phenols with hydrogen is described by Bjornson in U.S. Pat. No. 4,191,844. This reaction takes place in the presence of a catalyst consisting essentially of magnesium oxide and a Group IIA metal oxide such as manganese oxide. Although, these catalytic hydrodealkylation processes are more selective and cause less dehydroxylation than thermal hydrodealkylation, there still remains room for improvement. For example, the percentage of alkylated phenol converted to a new material is very low (about 40%) in the process described in U.S. Pat. No. 4,230,896 and dehydroxylation is still significant, providing 5-30 weight %

dehydroxylated products. When the alkylated phenols are reacted with hydrogen in the process described by Bjornson, the rate of dehydroxylation is also high producing large quantities of dehydroxylated products (up to 50 weight %) at high rates of dealkylation. In addition, these processes which
5 utilize a catalyst to dealkylate alkylated phenols are handicapped by the short lifetime of the catalyst due to coking. The catalyst must be reactivated or regenerated periodically and a deactivation suppressant is often necessary.

The disproportion of highly alkylated phenols with phenol over a tungsten oxide promoted magnesium oxide catalyst is described by Leach in
10 U.S. Pat. No. 4,125,736. The catalyst contained 0.5 to 15% tungsten oxide and the reaction was executed with 1 to 15% water resulting in o-cresol and p-cresol as the main products.

An acidic catalyst containing 75-100% aluminum oxide and 0-25% silica for the transmethylation of alkylated phenols in the presence of phenol or
15 cresol is described by Talley in U.S. Pat. No. 3,417,149. Talley in U.S. Pat. No. 4,533,767 describes the steam dealkylation of ortho and or para alkylated phenols without the loss of a hydroxyl radical without phenol present in the feed stream. In U.S. Pat. No. 4,533,786, Talley describes a similar steam dealkylation as described in U.S. Pat. No. 4,533,767, however, using zinc oxide
20 as the main component of the catalyst as opposed to magnesium oxide. In U.S. Pat. No. 4,560,810, Talley describes the ortho dealkylation alkylated hydroxyaromatic compounds using a combination of chromium oxide and one of the oxides of zinc, iron, magnesium, or manganese.

The suppression of the formation of highly alkylated phenols by a
25 catalytic transalkylation process comprising this invention provides high conversion rates, generally on the order of 25 weight percent or higher. In addition, the catalyst lifetime is extended for particular embodiments of this invention so as to reduce the frequency of regeneration.

SUMMARY OF THE INVENTION

A method for the suppression of highly alkylated phenols is provided comprising reacting an alkylated phenol with another phenol in the presence of a metal oxide catalyst, said alkylated phenol having at least one alkyl radical of from 1 to about 6 carbon atoms either ortho-positioned or para-positioned to the hydroxyl radical, and said phenol having at least one position available in the ortho- or para- position with respect to the hydroxyl radical.

An object of the invention is to suppress the formation of the undesired alkylated phenols by transalkylating the alkylated phenols into useful products by recycling these phenols into a normal alkylating feed stream.

Another object of the present invention is to transalkylate alkylated phenols at a high conversion rate without loss of selectivity.

Another object of the present invention is decrease the frequency at which the catalyst must be regenerated when transalkylating alkylated phenols by a catalytic steam transalkylating process.

DESCRIPTION OF THE DRAWINGS.

Not applicable.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed at the suppression of the formation of certain alkylated phenols by a catalytic transalkylating process that selectively transalkylates the ortho- and para-positioned alkyl groups with respect to the hydroxyl radical of an alkylated phenol. The term "dealkylating" as used herein, refers to the removal of alkyl groups, usually alkyl groups containing 1 to about 6 carbon atoms, from the aromatic nucleus of phenols. The term "transalkylating" as used herein, refers to the shift of the alkyl groups to another position on the aromatic ring within the same molecule or being positioned on the aromatic ring of another phenol. The term

"dehydroxylation" as used herein, refers to the loss of the hydroxyl radical on the aromatic nucleus of the phenols.

Suitable alkylated phenols which can be dealkylated or transalkylated by this process include those containing one hydroxyl radical and at least one
5 alkyl group at an ortho- and/or para-position relative to the hydroxyl radical. These alkylated phenols may contain multiple alkyl groups at various positions on the aromatic nucleus and these alkyl groups may be straight chain or branch chain. Examples of suitable alkylated phenols include isomers of cresol, isomers of xlenol, ethyl phenol, n-propylphenol, and
10 isomers of trimethylphenol, etc.; which contain at least one alkyl substituent on a para-, meta-, or ortho-position with respect to the hydroxyl radical. More particularly these include ortho-cresol, para-cresol, 2,4-xlenol, 2,3-xlenol, 2,5-xlenol, 2,6-xlenol, 2,3,4-trimethylphenol, 2,3,5-trimethylphenol, 2,3,6-trimethylphenol, 2,4,6-trimethylphenol, 2,4,5-trimethylphenol, 3,4,5-
15 trimethylphenol, 2-ethylphenol, 4-ethylphenol, 2,4-diethylphenol, etc. The feed of alkylated phenols may be comprised of one single alkylated phenol or a mixture of alkylated phenols; mixtures typically being derived from tar acids obtained from coal liquifaction processes or derived from the alkylating process itself.

20 Typical reactor feeds for transalkylation reactions comprise an alkyl radical acceptor, defined herein as a phenol having at least one ortho- or para-position vacant (e.g., phenol) and an alkyl radical donator, defined herein as a phenol with at least one alkyl radical at an ortho- or para- position (e.g., 2,4,6-trimethylphenol). The ratio of phenol that has at least one position available
25 in the ortho- or para- position with respect to the hydroxyl radical to alkylated phenols is generally within the range of 1:100 to 100:1. In a preferred embodiment, the ratio of phenol that has at least one position available in the ortho- or para- position with respect to the hydroxyl radical to

alkylated phenols is within the range of about 5:1 to about 25:1. A reactor feed may be comprised of one species which satisfies both descriptions, such as o-cresol. These reactions differ from the dealkylation reactions in that the preferred temperature range is lower, typically between about 425° to about
5 550°C.

The reactor feed may be substantially free of additional solvent or alternatively, the reactor feed may be dissolved in an organic solvent so as to make addition into the reactor easier. Any organic solvent which is inert under dealkylation conditions is suitable, provided it is a good solvent
10 medium for the alkylated phenols and the alkyl radical acceptor. In one preferred embodiment, the reaction is done under normal alkylation conditions wherein methanol and water are present in the feed that can serve the role of the solvent. In another preferred embodiment, the alkyl radical acceptor serves the role of the solvent. In an alternative preferred
15 embodiment, the preferred solvent is selected from the group consisting of benzene, toluene, hexane, and heptane. Other suitable solvents include tetrahydrofuran, chlorobenzene, hexane, etc.

The use of a catalyst comprised of about 60 to about 100 weight % magnesium oxide, about 0 to about 40 weight % manganese oxide and about
20 0 to about 20 weight % organic binder, preferably polyphenylene oxide, with or without a small amount of a promoter up to 5 weight %, wherein all weight are based upon the weight of the catalyst, provides a high degree of conversion of alkyl radical donators, particularly 2,4,6-trimethylphenol in excess phenol. In a preferred embodiment, the catalyst comprised of about 90
25 to about 99 weight % magnesium oxide and about 1 to about 5 weight % organic binder, and a small amount, typically about 0.1 weight %, of copper nitrate that acts as a promoter wherein all weight are based upon the weight of the catalyst. Utilizing the normal alkylating conditions and feed stock

extends the catalyst lifetime and provides a simple and efficient route to producing, e.g., o-cresol, p-cresol, 2,4-dimethylphenol and 2,6-dimethylphenol from 2,4,6-trimethylphenol.

5 The reaction between the unreacted and alkylated phenols and steam takes place in the presence of a catalyst comprised of metal oxide selected from the group consisting of Mg, Zn, Fe, V, Ce, Cs, Mn, or various combinations thereof. Any catalytic form of metal oxide is suitable for use in this process. It is preferable that the magnesium oxide within said catalyst fall within the range of about 60 to about 100% by weight, more preferably within
10 the range of about 90 to about 99 % by weight, based upon the weight of the catalyst.

These catalysts may have an inert organic or inorganic binder mixed within in order to permit them to be pelletized and easily handled in the process. Such binders may preferably comprise up to about 20 weight %, more preferably up to about 5 weight %, of said catalyst. Suitable organic
15 binders include: polyphenylene oxide, graphite, etc. Silica is an example of a suitable inorganic binder. In one embodiment of the present invention, polyphenylene oxide binders are the most preferred. The catalyst may also contain a promoter, for example, copper nitrate in the range of about 0.1 to
20 about 5 weight %.

Metal oxide catalysts retain their activity for several days with little loss of specific activity. However, over long periods of operation, carbon deposition (coking) gradually decreases that activity. When this occurs, the catalysts can be regenerated by oxidation of the carbon by passing oxygen or
25 air over the catalyst at temperatures in the range of about 400° to 500°C.

An alternative method utilized to retard the coking of the catalyst surface is to introduce an oxidizing atmosphere (oxygen, air, or another oxygen nitrogen mixture) into the reactor via the reactor feed so that the

reaction takes place in the presence of this oxidizing atmosphere, which is preferably air.

The rate at which alkylated phenols are fed into the reactor to react with unreacted phenols in the presence of catalyst is not critical to achieve the desired objects of this invention. The flow rate of reactants does effect the product yield by determining the amount of contact time between the alkylated phenol and catalyst. Due to the difference in the specific activities of metal oxide catalysts, each catalyst will have a different optimum flow rate than another. The more active the catalyst, the shorter contact time necessary to produce the same quantity of transalkylated phenols. Therefore, to obtain a particular conversion rate, higher weight hourly space velocities can be used with more active catalysts while lower weight hourly space velocities are necessary with less active catalysts. A flow rate which is too high will flood the catalyst and not permit the reaction to proceed. Where the catalyst utilized contains a promotor within the range of about 0.05 to 5 weight % and an organic binder within the range of about 0 to 20 weight %, a flow rate having a weight hourly space velocity in the range of about 0.1 to 3.0 grams alkylated phenol/hour/grams of catalyst is preferred. The most preferred flow rate is at a weight hourly space velocity of about 0.3 to 1.0 grams of alkylated phenol/hour/grams of catalyst. Both higher and lower flow rates can be utilized with such catalysts.

The starting materials are preferably in the vapor phase when in the presence of the metal oxide catalyst at the operable temperature ranges. To avoid cooling of the catalyst below the reaction temperature selected, it is preferable to vaporize and preheat the starting materials prior to contact with the metal oxide catalyst. To minimize the decomposition of the starting materials, it is most preferable to maintain the starting materials at the minimum temperature necessary to vaporize them and then preheat the

starting materials to the reaction temperature immediately prior to contact with the metal oxide catalyst. This can be accomplished by passing the vaporized starting materials through a heated tube of metal or quartz or by passing the vaporized starting materials over heated quartz beads just prior to entry into the catalyst bed. It is preferable to utilize the same heating medium to preheat the vapors which is used to heat the catalyst bed so as to maintain a stable reaction temperature within the reactor.

Both products and unreacted starting materials exit the metal oxide catalyst bed preferably in vapor form and are typically condensed to a liquid for subsequent use. This can be accomplished by any conventional means, such as common air or water condenser. The products are then separated from the condenser effluent, preferably by distillation in a conventional distillation apparatus.

The process can be carried out in a conventional reactor used for vapor phase reactions over a solid catalyst. For example, a tubular reactor of quartz or metal filled with a static bed of metal oxide catalyst is suitable. The reactor is heated to the desired temperature by any conventional means; for example, it can be heated by surrounding the reactor with an electric heater or by surrounding the reactor with a heated gas, liquid, or a fluidized solid medium.

In order that those skilled in the art may better understand this invention, the following experiments are provided by way of explanation and not by way of limitation.

All patents cited herein are incorporated herein by reference.

EXPERIMENTAL

In each of Examples 1 through 4, the following procedure was utilized:

A fluidized sand bath heated containing a U-shaped tubular reactor of 15 cm in length and having a diameter of about 1.2 cm was used with a

thermocouple inside to monitor the temperature of the catalyst bed.

The sand bath (enlarged Techne SBL-2) could control the temperature within about $\pm 5^{\circ}\text{C}$. The reactor was filled with the magnesium carbonate catalyst granules (size 700-1000 μm although different sieve fractions can be used) at the lowest part of the reactor. The catalyst was calcined at about 400 $^{\circ}\text{C}$ for about 21 hours while a nitrogen flow was maintained through the reactor. The reactor was then brought to the desired temperature.

The reactant feed was introduced using a Gipson HPLC pump (type 307) at a rate which provided a WHSV of 0.55, unless indicated otherwise.

The products in the effluent (abbreviated "effl" in the tables) which exited the reactor at the listed times were condensed and analyzed by GLC with a HP5890A chromatograph that was equipped with a HP1 column. The samples were collected and analyzed, at the times as stated in the tables.

The catalyst that was used in the experiments consists of about 97.6 weight % magnesium carbonate, about 2 weight % polyphenylene oxide, about 0.5 weight % graphite, and about 0.1 weight % copper nitrate, with all weights based on the weight of the catalyst. This catalyst was used unless stated otherwise.

Example 1

The feed consists of 18.9 weight % methanol and 27.0 weight % water with the remaining percentage as the phenols (i.e. phenol and 2,4,6-TMP) in the specified ratio. Listed in the table are only the phenol products in the effluent at the specified time.

Table 1.

	WHSV	Temp.	Phenol	o-cresol	p-cresol	2,6-DMP	2,4-DMP	2,4,6-TMP
Feed			50.0					50.0
effl 2h	0.86	475	53.6	22.2	1.1	15.2	3.3	4.3

The totals do not always add up to be 100% because not all products are listed, e.g., anisol, 2-methylanisol, 2-ethylphenol, 2,4,6-trimethylanisol, etc. Example 1 illustrates the opportunity of recycling mesitol (2,4,6-trimethylphenol) together with a normal feed stream of phenol, methanol and water.

Example 2

The feed consists of 48.0 weight % methanol and 16.7 weight % water with the remaining percentage as the phenols (i.e. phenol and 2,4,6-TMP) in the specified ratio. Listed in the table are only the phenol products in the effluent at the specified time.

Table 2.

	WHSV	Temp.	Phenol	o-cresol	p-cresol	2,6-DMP	2,4-DMP	2,4,6-TMP
Feed			95.0					5.0
#1								
effl	0.55	460	7.1	10.1	0.03	71.52	.49	9.0
50h								
effl	0.55	460	15.0	10.4	0.02	65.8	.23	7.9
362h								
Feed			100.0					
#2								
effl	0.55	460	8.5	10.6	0.03	69.5	0.41	9.6
50h								
effl	0.55	460	19.3	20.7	0.19	50.2	1.22	7.1
362h								

A reference reaction was run at the same time in the same sand bath to ensure a good comparison with the same temperature profile.

The reaction with 5% mesitol in the feed from the start showed a somewhat suppressed 2,6-xylenol formation during the first 50 hours but on the other side it also did produce significantly less mesitol. After this period

the formation of 2,6-xylenol became normal and even a little higher than the reference reaction. This finally resulted in the formation of 505 grams of 2,6-xylenol versus 372 grams of 2,6-xylenol from the reference reaction.

The amount of mesitol in the effluent after 362 hours was 76 grams and
5 of the reference reaction 78 grams which was the same. But during this time the reaction with 5 % mesitol in the feed had fed the reactor with 35 grams of mesitol which means that all of that is transformed to other substances. This leads to the conclusion that approximately 50% of the mesitol formation is suppressed since the net mesitol formation was now 41 grams and the net
10 mesitol production of the reference reaction was 78 grams during the same time.

Example 3 (Catalyst: manganese oxide and magnesium oxide is a ratio of 1:3 + binder additives)

The feed consists of 48.0 weight % methanol and 16.7 weight % water with the
15 remaining percentage as the phenols (i.e. phenol and 2,4,6-TMP) in the specified ratio. Listed in the table are only the phenol products in the effluent at the specified time.

Table 3.

	WHSV	Temp.	Phenol	o-cresol	p-cresol	2,6-DMP	2,4-DMP	2,4,6-TMP
Feed			95.0					5.0
#1								
effl	0.55	450	33.7	47.2	0.10	13.7	0.57	4.43
50h								
effl	0.55	453	56.9	35.2	0.07	2.8	0.30	4.51
98h								
Feed			100.0					
#2								
effl	0.55	450	41.9	51.7	0.10	4.7	0.33	0.06
50h								
effl	0.55	453	58.2	35.7	0.11	4.6	0.19	0.06
98h								

The effluent composition contained almost over the whole run less than 5 weight % mesitol, which is less than was present in the feed even if the amount is corrected for the molecular weight gain.

Example 4

The feed consists of 48.0 weight % methanol and 16.7 weight % water with the remaining percentage as the phenols (i.e. phenol and 2,4-DMP) in the specified ratio. Listed in the table are only the phenol products in the effluent at the specified time.

Table 4.

	WHSV	Temp.	Phenol	o-cresol	p-cresol	2,6-DMP	2,4-DMP	2,4,6-TMP
Feed			95.0				5.0	
#1								
effl	0.55	450	11.7	28.5	0.38	44.1	3.84	10.7
49h								

effl	0.55	450	2.4	16.5	0.04	68.3	1.39	10.3
170h								
Feed			100.0					
#2								
effl	0.55	450	8.3	28.1	0.27	46.6	2.93	11.9
49h								
effl	0.55	450	9.5	17.8	0.11	58.7	1.49	11.0
170h								

This reaction shows this technique is not limited to 2,4,6-trimethylphenol but can be applied for other alkylated phenols as well. In this example the same procedure is used for 2,4-dimethylphenol showing again good suppression. Moreover, there was no net formation of 2,4-xyleneol which is considered an unwanted by-product in some alkylation reactions.

Although the above Examples have shown various modifications of the present invention, further modifications are possible in light of the above techniques by one skilled in the art without departing from the scope and spirit of this invention.



CLAIMS

What is claimed is:

1. A method of suppression of the formation of highly alkylated phenol during an alkylation reaction by removing or transposing one or more alkyl radicals that are ortho- or para- positioned with respect to the hydroxyl radical of alkylated phenols comprising reacting an alkylated phenol with a phenol that has at least one position available in the ortho- or para- position with respect to the hydroxyl radical in the presence of a catalyst comprising a metal oxide selected from the group consisting of Mg, Zn, Fe, V, Ce, Cs, Mn, or combination thereof at a temperature in the range of about 400° to 675° C., said alkylated phenols having at least one alkyl radical either ortho-
5 positioned or para-positioned to the hydroxyl radical, the alkyl radicals of
10 said alkylated phenols having from 1 to about 6 carbon atoms.
2. The method of claim 1, further comprising an oxidizing atmosphere that is selected from the group consisting of air and oxygen.
3. The method of claim 1, wherein the flow rate of alkylated phenols is within the range of 0.1 to 3.0 grams/hour/gram of catalyst.
4. The method of claim 1, wherein the weight ratio of alkylated phenol to phenol that has at least one position available in the ortho- or para- position with respect to the hydroxyl radical is in the range of about 1:100 to 100:1.
5. The method of claim 1, wherein the reaction takes place under a pressure within the range of about 1 to 5 atmospheres.
6. The method of claim 1, wherein the catalyst is comprised of about 60 to 100 weight % magnesium oxide, about 0 to 40 weight % manganese oxide and about 0 to 20 weight % of an organic binder, with or without a small amount of a promoter of up to 5 weight %, wherein all the weights are based upon the weight of the catalyst.



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7. The method of claim 6, wherein the organic binder is polyphenylene oxide.

8. The method of claim 6, wherein the ratio of phenol that has at least one position available in the ortho- or para- position with respect to the hydroxyl radical to alkylated phenols is within the range of 1:100 to 100:1.

9. The method of claim 6, wherein the temperature is maintained within the range of about 425° to 550° C. and the pressure is maintained at about 1 atmosphere.

10. The method of claim 6, wherein the flow rate of alkylated phenols is within the range of about 0.1 to 3.0 grams/hour/gram of catalyst.

11. The method of claim 1, wherein the alkylated phenols are selected from the group consisting of o-cresol, p-cresol, 2,4-xylenol, 2,6-xylenol, 2,5-xylenol, 2,3-xylenol, 3,4-xylenol, 2,4,6-trimethylphenol, 2,3,5-trimethylphenol, 2,3,6-trimethylphenol, 2,3,4-trimethylphenol and 3,4,5-
5 trimethylphenol.

12. The method of claim 1, wherein the alkylated phenols are dissolved in a solvent.

13. The method of claim 12, wherein the solvent is water, methanol, or a combination thereof.

14. The method of claim 12, wherein the solvent is selected from the group consisting of benzene, toluene, hexane, and heptane.

15. A method of transalkylating alkylated phenols selected from the group consisting of 2,4-xylenol, 2,6-xylenol, 2,4,6-trimethylphenol, o-cresol and p-cresol, said method comprising reacting one or more of said alkylated phenols with an unreacted phenol or phenols with at least one position
10 available in the ortho- or para- position with respect to the hydroxyl radical in the presence of a catalyst comprising about 60 to about 100 weight %



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magnesium oxide, about 0 to about 40 weight % manganese oxide and about 0 to about 20 weight % polyphenylene oxide, with or without a small amount of a promoter up to 5 weight %, at a temperature in the range of about 425° to 550°C., the ratio of total phenols to steam falling within the range of about

5 1:0.2 to 1:5.

16. The method of claim 15, wherein the flow rate of reactants falls within the range of about 0.1 to 3.0 grams/hour/gram of catalyst.

17. The method of claim 15, wherein the organic binder is polyphenylene oxide.

18. A method of reducing the formation of 2,4,6-trimethylphenol by transalkylating 2,4,6-trimethylphenol with substantially no dehydroxylation wherein 2,4,6-trimethylphenol is reacted with steam in the presence of a catalyst comprised of about 60 to about 100 weight % magnesium oxide, about 0 to about 40 weight % manganese oxide and a polyphenylene oxide organic binder, said flow rate of 2,4,6-trimethylphenol falling within the range of about 0.1 to 1.5 WHSV, said ratio of steam to phenol falling within the range of about 0.5:1 to 15:1, said temperature range falling within the range of about 425° to 550 °C. and said pressure being at about 1 atmosphere.

19. A method of reducing the formation of 2,4-dimethylphenol by transalkylating 2,4-xilenol with substantially no dehydroxylation, wherein 2,4-xilenol is reacted with steam and methanol in the presence of a catalyst
10 comprised of about 60 to about 100 weight % magnesium oxide, about 0 to about 40 weight % manganese oxide, and about 0 to about 20 weight % of a polyphenylene oxide organic binder, with or without a small amount of a promoter in an amount up to about 5 weight %, said flow rate of 2,4-xilenol falling within the range of about 0.1 to 3.0 grams/hour/gram of catalyst, said
15 phenol to steam ratio falling within the range of about 1:0.2 to 1:15, said





temperature falling within the range of about 425° to 550° C. and said pressure being at about 1 atmosphere.

20. A method of reducing the formation of certain alkylated phenols by transalkylating ortho and para positioned alkyl radicals of alkylated phenols to phenols having at least one ortho or para position vacant, said process comprising reacting in the vapor phase an alkyl radical donator consisting of an alkylated phenol having at least one alkyl radical at an ortho or para position with an alkyl radical acceptor consisting of a phenol having at least one ortho or para position vacant and a catalyst at a temperature in the range of about 400°-550° C., said alkyl radical having from 1 to 6 carbon atoms and said catalyst comprising a metal oxide, from the group consisting of Mg, Zn, Fe, V, Ce, Cs, Mn, or combination thereof, about 60 to about 100 weight % magnesium oxide, about 0 to about 40 weight % manganese oxide and about 0 to about 20 weight % organic binder with or without a small amount of a promoter in an amount up to about 5 weight %.

21. The method of claim 20, wherein the alkyl radical is a methyl group.

22. The method of claim 20, wherein the organic binder is polyphenylene oxide.

23. The method of claim 20, wherein said alkyl radical donator is selected from the group consisting of 2,4,6-trimethylphenol, 2,4-xyleneol, 2,6-xyleneol, o-cresol and p-cresol and said alkyl radical acceptor is selected from the group consisting of phenol, o-cresol, p-cresol, 2,4-xyleneol and 2,6-xyleneol.

24. The method of claim 23, wherein said alkyl radical acceptor is different from said alkyl radical donator and the molar ratio of said alkyl radical acceptor to alkyl radical donator is within the range of 1:100 to 100:1.



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**SUPPRESSION OF HIGHLY ALKYLATED PHENOLS IN THE CATALYTIC
ALKYLATION REACTION OF PHENOL**

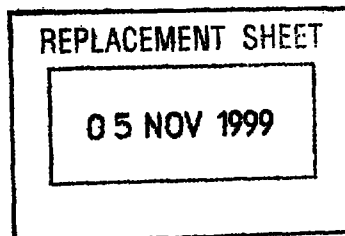
ABSTRACT

Selective catalytic reduction of the formation of alkylated phenols by transalkylation of ortho- and para-positions of alkylated phenols is accomplished by reacting ortho- and/or para-alkylated phenols with unreacted alkylated phenols in the presence of a metal oxide selected from the
5 group consisting of Mg, Zn, Fe, V, Ce, Cs, Mn, or combinations thereof. This invention can be easily executed by recycling the alkylated phenols into the normal feed stream of the alkylation reactor.

CLAIMS

What is claimed is :

1. A method of suppression of the formation of highly alkylated phenol, comprising:
 - introducing a feed stream to a metal oxide catalyst, said feed stream comprising phenol having at least one position available in the ortho- or para-position with respect to the hydroxyl radical;
 - producing a first effluent stream comprising alkylated phenol having at least one alkyl radical either ortho- or para- positioned to the hydroxyl radical;
 - introducing at least a portion of said first effluent stream to said feed stream; and
 - reacting said phenol with said alkylated phenol to produce a second effluent stream.
2. A method as in Claim 1, wherein the percentage of alkylated phenol in said first effluent stream is substantially equal to the percentage of alkylated phenol in said second effluent stream.
3. A method as in Claim 1, further comprising introducing at least a portion of said second effluent stream the catalyst.
4. A method as in Claim 1, wherein production of 2,4,6-mesitol is suppressed approximately 50%.
5. A method as in Claim 1, wherein production of 2,4-dimethyl phenol is suppressed more than 50%.
6. A method as in Claim 1, further comprising dissolving said phenol in a solvent prior to introduction to said catalyst, wherein said solvent is methanol, water or a combination thereof.
7. A method as in Claim 1, further comprising dissolving said phenol in a solvent prior to introduction to said catalyst, wherein said solvent is benzene, toluene, hexane, or heptane.



8. A method as in Claim 1, wherein said first effluent stream and said second effluent stream comprise 2,4,6-mesitol, and wherein the percent of 2,4,6-mesitol in said second effluent stream is about equivalent to or less than the percent of 2,4,6-mesitol in said first effluent stream.
9. A method as in Claim 1, wherein said first effluent stream and said second effluent stream comprise 2,4-dimethyl phenol, and wherein the percent of 2,4-dimethyl phenol in said second effluent stream is about equivalent to or less than the percent of 2,4-dimethyl phenol in said first effluent stream.
10. A method as in Claim 1, wherein the catalyst is comprised of about 60 to 100 weight % magnesium oxide, about 0 to 40 weight % manganese oxide and about 0 to 20 weight % of an organic binder, and 0 to 5 weight %, wherein all the weights are based upon the weight of the catalyst.
11. A method as in Claim 10, wherein the catalyst is maintained at a temperature of about 425° to 550° C.
12. A method as in Claim 10, wherein said alkylated phenol has a flow rate of about 0.1 to 3.0 grams/hour/gram of catalyst.
13. A method as in Claim 1, wherein said alkylated phenol is o-cresol, p-cresol, 2,4-xyleneol, 2,6-xyleneol, 2,5-xyleneol, 2,3-xyleneol, 3,4-xyleneol, 2,4,6-trimethylphenol, 2,3,5-trimethylphenol, 2,3,6-trimethylphenol, 2,3,4-trimethylphenol, 3,4,5-trimethylphenol, or a combination thereof.
14. A method for producing 2,6-xyleneol, comprising:
introducing phenol to a metal oxide catalyst, said phenol having at least one position available in the ortho- or para- position with respect to the hydroxyl radical;



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maintaining the temperature of the catalyst at about 400°C to about 675°C;

producing a first effluent stream comprising alkylated phenol having at least one alkyl radical either ortho- or para- positioned to the hydroxyl radical;

introducing additional phenol and at least a portion of said first effluent stream to the catalyst; and

reacting said additional phenol with said alkylated phenol to produce a second effluent stream.

15. A method as in Claim 14, further comprising introducing at least a portion of said second effluent stream to the catalyst.

16. A method as in Claim 14, wherein production of mesitol is suppressed approximately 50%.

17. A method as in Claim 14, wherein production of 2,4-dimethyl phenol is suppressed more than 50%.

18. A method as in Claim 14, further comprising dissolving said phenol in a solvent prior to introduction to said catalyst, wherein said solvent is methanol, water or a combination thereof.

19. A method as in Claim 14, further comprising dissolving said phenol in a solvent prior to introduction to said catalyst, wherein said solvent is benzene, toluene, hexane, or heptane.

20. A method as in Claim 14, wherein said first effluent stream and said second effluent stream comprise 2,4,6-mesitol and 2,4-dimethyl phenol.

21. A method as in Claim 14, wherein said first effluent stream and said second effluent stream comprise 2,4,6-mesitol, and wherein the percent of 2,4,6-mesitol in said second effluent stream is about equivalent to or less than the percent of 2,4,6-mesitol in said first effluent stream.



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22. A method as in Claim 14, wherein said first effluent stream and said second effluent stream comprise 2,4-dimethyl phenol, and wherein the percent of 2,4-dimethyl phenol in said second effluent stream is about equivalent to or less than the percent of 2,4-dimethyl phenol in said first effluent stream.

23. A method as in Claim 14, wherein the catalyst is comprised of about 60 to 100 weight % magnesium oxide, about 0 to 40 weight % manganese oxide and about 0 to 20 weight % of an organic binder, and 0 to 5 weight %, wherein all the weights are based upon the weight of the catalyst.

24. A method as in Claim 23, wherein the catalyst is maintained at a temperature of about 425° to 550° C.

25. A method as in Claim 23, wherein said alkylated phenol has a flow rate of about 0.1 to 3.0 grams/hour/gram of catalyst.

26. A method as in Claim 23, wherein said alkylated phenol is o-cresol, p-cresol, 2,4-xyleneol, 2,6-xyleneol, 2,5-xyleneol, 2,3-xyleneol, 3,4-xyleneol, 2,4,6-trimethylphenol, 2,3,5-trimethylphenol, 2,3,6-trimethylphenol, 2,3,4-trimethylphenol, 3,4,5-trimethylphenol, or a combination thereof.

