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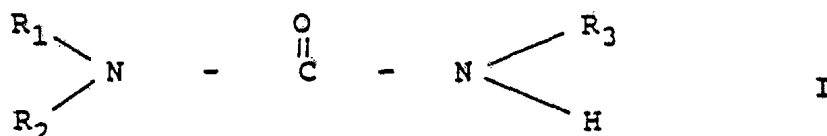
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 PROCESS FOR THE N-ALKYLATION OF UREAS
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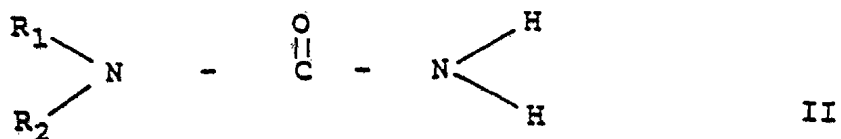
The invention relates to a process for the preparation of N-alkylated ureas by reacting a urea with an alkylating agent.

CLAIM

1. Process for the preparation of ureas of the formula



in which R₁ and R₂ independently of one another denote hydrogen, a linear, branched or cyclic alkyl group which is unsubstituted or substituted by groups inert under the conditions of the reaction, or an aralkyl group, or R₁ and R₂, together with the nitrogen atom, denote a non-aromatic, heterocyclic ring and R₃ denotes an alkyl group which is unsubstituted or substituted by groups inert under the conditions of the reaction, the tertiary butyl group being excluded, comprising N-alkylating a urea of the formula



in which R_1 and R_2 have the abovementioned meaning in the presence of a solid base used in excess relative to the urea of formula (II) and in the presence of a phase transfer catalyst in a diluent at temperatures of 0 to 150°C with an alkylating agent of the formula



in which R_3 has the meaning indicated above and n denotes the numbers 1 or 2, X representing a halide or a sulfonic acid or bisulfate group in the event that n denotes the number 1, and X representing a sulfate group in the event that n denotes the number 2.

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641038

ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT



Invention Title: PROCESS FOR THE N-ALKYLATION OF UREAS



The following statement is a full description of this invention, including the best method of performing it known to us:



GH&CO REF: 13985-V:ECA:RK

Process for the N-alkylation of ureas

The invention relates to a process for the preparation of N-alkylated ureas by reacting a urea with an alkylating agent.

5 Hitherto, it has been necessary to prepare N-alkylated ureas by indirect routes, namely, for example, via the preparation of an amine, which had to be substituted correspondingly to the desired urea, and which was then reacted with the urea by exchange of an
10 amine moiety of the urea or was reacted with an appropriate isocyanate or carbamoyl chloride. A direct N-alkylation of ureas with alkylating agents has hitherto been considered impossible.

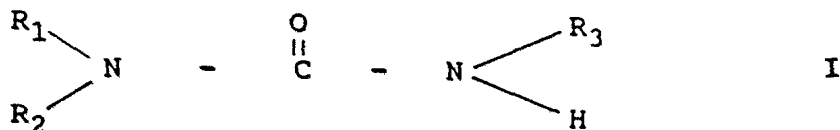
Thus it is described in R.A. Jacobson, J.Am.Chem.Soc. 58, 1984 (1936) that the attempt to
15 alkylate ureas on the nitrogen atom by reacting monosodium ureas with alkyl halides did not proceed successfully. It is evident from P.A. Ongley, Trans.Proc.Roy. Soc., New Zealand 77, 10 (1948) that alkylisoureas and not N-alkylated ureas are formed when urea is alkylated
20 with alkyl sulfates. These results are confirmed in F. Korte: Methodicum Chemicum, Volume 6, 716 and 732, Georg Thieme Verlag, Stuttgart, 1974. It is described therein that ureas are always alkylated on the oxygen atom and not on the nitrogen atom when reacted with alkyl halides,
25 and that isoureas are formed when ureas are alkylated with dialkyl sulfates or esters of p-toluene sulfonic acid.

U. Petersen and E. Kühle in E. Müller: Methoden der Organischen Chemie ("Methods of Organic Chemistry")
30 (Houben-Weyl); 4th edition, volume E4, 335 et seq and 594, Georg Thieme Verlag Stuttgart - New York, 1983 and the literature quoted therein also confirm that only O-alkylation of ureas is possible.

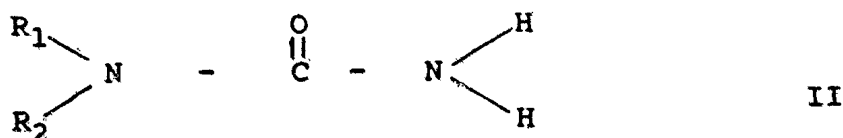
35 It has now been found, unexpectedly, that ureas can, however, be alkylated on the nitrogen atom if the urea is reacted with an alkylating agent in the presence of a phase transfer catalyst and a base.

The invention therefore relates to a process for

the preparation of ureas of the formula



in which R_1 and R_2 independently of one another denote hydrogen, a linear, branched or cyclic alkyl group which is unsubstituted or substituted by groups inert under the conditions of the reaction, or an aralkyl group, or R_1 and R_2 , together with the nitrogen atom, denote a non-aromatic, heterocyclic ring and R_3 denotes an alkyl group which is unsubstituted or substituted by groups inert under the conditions of the reaction, the tertiary butyl group being excluded, characterized in that a urea of the formula

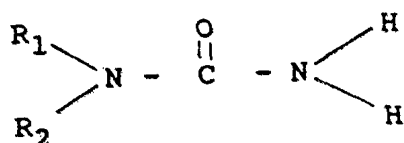


in which R_1 and R_2 have the abovementioned meaning is N-alkylated in the presence of a solid base and in the presence of a phase transfer catalyst in a diluent at temperatures of 0 to 150°C with an alkylating agent of the formula



in which R_3 has the meaning indicated above and n denotes the numbers 1 or 2, X representing a halide or a sulfonic acid or bisulfate group in the event that n denotes the number 1, and X representing a sulfate group in the event that n denotes the number 2.

The urea employed has the formula



II

wherein R_1 and R_2 independently of one another denote hydrogen, a linear, branched or cyclic alkyl group which is unsubstituted or substituted by groups inert under the conditions of the reaction, or an aralkyl group, or R_1 and R_2 , together with the nitrogen atom, denote a non-aromatic heterocyclic ring.

Alkyl groups are to be understood here as meaning alkyl groups having 1 to 22, preferably 2 to 18, C atoms, such as, for example, ethyl, propyl, isopropyl, tert.-butyl, isopentyl, methylcyclopentyl, cyclohexyl, 3-ethylhexyl, octyl, decyl, dodecyl, hexadecyl or octadecyl groups.

The alkyl groups can be unsubstituted or substituted by groups inert under the conditions of the reaction, such as, for instance, fluorine atoms, nitro groups, alkenyl, alkylidene or aryl groups or alkoxy groups having 1 to 5 C atoms, for example methoxy, ethoxy, isopropoxy, butoxy or phenoxy groups. The alkyl groups are preferably unsubstituted.

Aralkyl groups are to be understood as meaning benzyl or phenylethyl groups, it being possible for the phenyl groups to be substituted by groups inert under the conditions of the reaction, such as alkyl groups having 1 to 5 C atoms, for example ethyl, isopropyl or isopentyl groups, alkoxy groups having 1 to 5 C atoms, for example methoxy, ethoxy, isopropoxy or butoxy groups, halides, such as fluorine, chlorine or bromine, or nitro groups. R_1 and R_2 , together with the nitrogen atom, can also form a non-aromatic, heterocyclic ring, that is to say, for example, a pyrrolidine, piperidine, morpholine or 1,4-thiazane ring.

R_1 and R_2 independently of one another preferably denote hydrogen or an unsubstituted, linear or branched alkyl group having 2 to 10 C atoms, or R_1 and R_2 , together

with the nitrogen atom, denote a non-aromatic, heterocyclic ring, preferably the pyrrolidine or morpholine ring.

5 Compounds of the formula II can either be prepared by means of the process according to the invention or they can be prepared by one of the customary, known processes, for instance by reacting urea or isocyanic acid with a suitable amine.

10 Suitable bases are solid bases, such as alkali metal hydroxides, for example potassium hydroxide or sodium hydroxide, or alkali metal amides, for example sodium amide or potassium amide. It is preferable to employ alkali metal hydroxides, and it is advantageous if the alkali metal hydroxide has a small content of a carbonate, such as potassium carbonate or sodium carbonate, amounting to 2 to 20 mol%, relative to the alkali metal hydroxide. The base is used in excess in a solid, powdered form or in the form of pellets. It is preferable to use 1.5 to 8 mol, particularly preferably 3 to 5 mol, of the solid base per mole of urea of the formula II.

20 Suitable catalysts are customary phase transfer catalysts or dimethyl sulfoxide. A summary of phase transfer catalysts which can be used and their possible use in various diluents is disclosed in W.E. Keller: Phase transfer reactions (Fluka Compendium), volumes 1 and 2; Georg Thieme Verlag Stuttgart - New York, 1986 and 1987. It is preferable to employ quaternary ammonium salts, such as, for example, tetrabutylammonium bisulfate, tetrabutylammonium chloride or benzyltriethylammonium chloride, as the phase transfer catalysts. If urea itself is used as the urea of the formula II, dimethyl sulfoxide is used as the catalyst. The choice of the catalyst in a particular case is made on the basis of the particular diluent used or the particular starting material used.

35 The alkylating agent employed is a compound of the formula



III

in which R_3 denotes an alkyl group which is unsubstituted or substituted by groups inert under the conditions of the reaction, the tert.-butyl group being excluded, and n denotes the number 1 or 2, X representing a halide or a sulfonic acid or bisulfate group in the event that n denotes the number 1, and X representing a sulfate group in the event that n denotes the number 2. A halide is to be understood here as meaning chloride, bromide or iodide. X in the formula III preferably denotes a halide, a sulfonic acid group or a sulfate group. Alkyl groups are to be understood as meaning the alkyl groups mentioned above, which can be unsubstituted or substituted by groups inert under the conditions of the reaction, such as are mentioned above, the tert.-butyl group being excluded. The alkylating agent is generally employed in an equimolar ratio to the urea of the formula II, it being possible, however, to use an excess of one or other of the reactants in an individual case.

The diluents employed are diluents which are inert under the conditions of the reaction and which are solvents for the urea of the formula II and the alkylating agent. These are aromatic hydrocarbons, for example benzene, toluene or xylene, higher aliphatic hydrocarbons, for example paraffins, aromatic halogenated hydrocarbons, for example chlorobenzene or trichlorobenzenes, ethers, for example tetrahydrofuran, or dimethyl sulfoxide or mixtures of such diluents. It is preferable to employ aromatic hydrocarbons or dimethyl sulfoxide, particularly preferably toluene or dimethyl sulfoxide. If dimethyl sulfoxide is used as the diluent, it also acts at the same time as the catalyst. The base employed should not be completely soluble in the diluent used. If the starting material of the formula II is urea, dimethyl sulfoxide is used as the diluent.

The process according to the invention may be carried out by initially taking the urea of the formula II,



also
dissolved in the diluent. It is/preferable for the
diluent to have been dried before use. The solid base is
then added in the form of pellets or in a powdered form
and is thoroughly suspended by vigorous stirring, after
5 which the catalyst and the alkylating agent are added. It
has been found that, if dimethyl sulfoxide is used as the
catalyst and diluent, it can be advantageous first to
suspend the pelletized or powdered solid base thoroughly
in dimethyl sulfoxide and then to stir in the urea of the
10 formula II and the alkylating agent, it being preferable
in this case to employ an alkyl halide as the alkylating
agent.

The reaction mixture is vigorously stirred and,
if appropriate, heated to temperatures up to 150°C. It is
preferably heated to 70 to 150°C, particularly preferably
to the reflux temperature of the particular diluent used.
In the event that dimethyl sulfoxide is used as the
catalyst and diluent, the reaction mixture is not heated
to reflux temperature; in this case a temperature of 0 to
20 100°C, preferably 20 to 70°C, is used.

The urea of the formula I is formed in the course
of the reaction.

When the reaction is complete, water is added and
the urea of the formula I is extracted from the reaction
mixture by means of an extraction agent. The extraction
25 agents employed are water-immiscible, organic extraction
agents, such as halogenated hydrocarbons, for example
methylene chloride or chloroform, or ethers, for example
diethyl ether or diisopropyl ether. The organic phase is
30 washed with water and dried, and the diluent is evapor-
ated off, it being possible for a subsequent drying in
vacuo to be carried out. In general, the purity of the
urea of the formula I prepared in this manner is
adequate. If necessary, a purification stage, for example
35 by recrystallization, chromatography or distillation, can
also follow.

In a preferred embodiment, ethyl-, isopropyl-,
butyl-, tert.-butyl- or decyl-urea or pyrrolidine carbox-
amide or morpholine carboxamide is dissolved in toluene,



3 to 5 equivalents of potassium hydroxide or sodium hydroxide pellets containing 4 to 10 mol% of potassium carbonate or sodium carbonate are added with vigorous stirring, together with 0.04 to 0.06 equivalent of a quaternary ammonium salt as phase transfer catalyst, and one equivalent of alkyl halide or alkyl sulfonate as alkylation agent, and the mixture is heated at reflux temperature. When the reaction is complete, water is added to the reaction mixture and it is extracted several times with methylene chloride and/or chloroform. The combined organic phases are washed with water and dried, and the diluent is evaporated off, after which the product is subsequently dried in vacuo.

In another preferred embodiment, 3 to 5 equivalents of powdered potassium hydroxide are suspended in dimethyl sulfoxide, and one equivalent of urea and one equivalent of alkyl halide are added. The reaction mixture is stirred at temperatures from 20 to 70°C, water is added when the reaction is complete, and the mixture is extracted with methylene chloride and/or chloroform. The combined organic phases are dried and the diluent is evaporated off, after which a further drying is carried out under an oil pump vacuum.

Alkylated ureas are prepared in the manner described in good yields and in a good state of purity without indirect routes. The process thus constitutes an enrichment of the art.

Example 1

2.32 g of N-butylurea (20 mmol), 3.2 g of NaOH pellets (80 mmol), 0.55 g of potassium carbonate (4 mmol) and 280 mg (1 mmol) of tetrabutylammonium chloride were suspended in 40 ml of toluene, and 2.18 g of ethyl bromide (20 mmol) were added with vigorous stirring. The reaction mixture was heated at reflux temperature for 2 hours, 150 ml of distilled water were added, and the mixture was extracted with 50 ml of chloroform and 50 ml of methylene chloride. The combined organic phases were washed with water, dried over sodium sulfate and evaporated. The residue was dried further in vacuo. This gave



2.16 g of N-butyl-N'-ethylurea, i.e. 76% of theory.

¹H-NMR (CDCl₃; 200 MHz; delta): 5.874 (s broad; 2H; NH); 3.220-3.125 (m(dt and dq); 4H; N-CH₂); 1.460-1.320 (m(tt and tq); 4H; butyl-CH₂-CH₂); 1.112 (t; 3H; ethyl-CH₃; J_E = 6.5 Hz); 0.858 (t; 3H; butyl-CH₃; J_B = 6.5 Hz) ppm.

Example 2

N-butyl-N'-propylurea was prepared in a yield of 78% of theory as described in Example 1, but using 2.46 g of propyl bromide as the alkylating agent.

¹H-NMR (CDCl₃; 200 MHz; delta): 5.864 and 5.836 (2t; each 1H; NH); 3.104 (2dt; each 2H; N-CH₂; J_{CH₂NH} = 6.0 Hz; J_{CH₂-CH₂} = 7.4 Hz); 1.542-1.349 (m(tt and 2tq); 6H; butyl-CH₂-CH₂ and propyl-CH₂); 0.906 (t; 6H; butyl-CH₃ and propyl-CH₃; J = 7.3 Hz) ppm.

Example 3

N-butyl-N'-ethylurea was obtained in a yield of 52% of theory as described in Example 1, but using 4.5 g of KOH pellets (80 mmol) and 0.55 g of potassium carbonate (4 mmol) as the bases and heating at reflux temperature for 16 hours. The ¹H-NMR spectrum was entirely identical with that of Example 1.

Example 4

N-butyl-N'-ethylurea was obtained in a yield of 80% of theory as described in Example 1, but using 1.54 g of diethyl sulfate (10 mmol) as the alkylating agent. The ¹H-NMR spectrum was entirely identical with that of Example 1.

Example 5

N-butyl-N'-ethylurea was obtained in a yield of 74% of theory as described in Example 1, but using 4.0 g of ethyl toluene-4-sulfonate (20 mmol) as the alkylating agent. The ¹H-NMR spectrum was entirely identical with that of Example 1.

Example 6

N-butyl-N'-ethylurea was obtained in a yield of 71% of theory as described in Example 1, but using 2.48 g of ethyl methanesulfonate (20 mmol) as the alkylating agent. The ¹H-NMR spectrum was entirely identical with that of Example 1.

Example 7

N-butyl-N'-ethylurea was obtained in a yield of 71% of theory as described in Example 1, but using 1.76 g of N-ethylurea (20 mmol) as the urea and 2.74 g of butyl bromide (20 mmol) as the alkylating agent. The ¹H-NMR spectrum was entirely identical with that of Example 1.

Example 8

N-butyl-N'-isopropylurea was prepared in a yield of 58% as described in Example 1, but using 2.04 g of N-isopropylurea (20 mmol) as the urea and 2.74 g of butyl bromide (20 mmol) as the alkylating agent.

¹H-NMR (CDCl₃; 200 MHz; delta): 5.708 (t; 1H; butyl-NH; J_{CH₂NH} = 5.5 Hz); 5.490 (d; 1H; isopropyl-NH; J_{CHNH} = 7.9 Hz), 3.858 (dq; 1H; isopropyl-CH; J_{CHNH} = 7.9 Hz; J_{CHCH₃} = 6.5 Hz); 3.135 (dse; 2H; butyl-N-CH₂; J_{CH₂NH} = 5.5 Hz; J_{CH₂CH₂} = 6.7 Hz); 1.498-1.275 (m(tt and tq); 4H; butyl-CH₂-CH₂); 1.122 (d; 6H; isopropyl-CH₃; J_{CHCH₃} = 6.5 Hz); 0.906 (t; 3H; butyl-CH₃; J_{CH₂CH₃} = 7.0 Hz) ppm.

Example 9

N-butyl-N'-isopropylurea was prepared in a yield of 35% of theory as described in Example 1, but using 2.46 g of 2-bromopropane (20 mmol) as the alkylating agent. The ¹H-NMR spectrum was entirely identical with that of Example 8.

Example 10

N,N'-dibutylurea was obtained in a yield of 82% of theory as described in Example 1, but using 2.74 g of butyl bromide (20 mmol) as the alkylating agent.

¹H-NMR (CDCl₃; 200 MHz; delta): 5.914 (t; 2H; NH; J_{CH₂NH} = 5.9 Hz); 3.135 (dt; 4H; N-CH₂; J_{CH₂NH} = 5.9 Hz; J_{CH₂CH₂} = 6.7 Hz); 1.497-1.315 (m(tt and tq); 8H; butyl-CH₂-CH₂); 0.908 (t; 6H; CH₃); J_{CH₂CH₃} = 7.0 Hz) ppm.

Example 11

N,N'-dibutylurea was obtained in a yield of 75% of theory as described in Example 10, but using 4.5 g of KOH pellets (80 mmol) and 0.55 g of potassium carbonate (4 mmol) as the base and heating at reflux temperature for 12 hours. The ¹H-NMR spectrum was entirely identical with that of Example 10.

Example 12

N,N'-dibutylurea was obtained in a yield of 67% of theory as described in Example 1, but using 1.85 g of butyl chloride (20 mmol) as the alkylating agent and 4.5 g of KOH pellets (80 mmol) and 0.55 g of potassium carbonate (4 mmol) as the base and heating at reflux temperature for 12 hours. The ¹H-NMR spectrum was entirely identical with that of Example 10.

Example 13

N,N'-dibutylurea was obtained in a yield of 21% of theory as described in Example 1, but using 1.85 g of butyl chloride (20 mmol) as the alkylating agent. The ¹H-NMR spectrum was entirely identical with that of Example 10.

Example 14

N-butyl-N'-tert.-butylurea was obtained in a yield of 47% of theory as described in Example 1, but using 2.32 g of tert.-butylurea (20 mmol) as the urea and 2.74 g of butyl bromide (20 mmol) as the alkylating agent.

¹H-NMR (CDCl₃; 200 MHz; delta): 5.421 (t; 1H; butyl-NH; J_{CH₂NH} = 6.0 Hz); 5.239 (s; 1H; tert.-butyl-NH); 3.093 (dt; 2H; N-CH₂; J_{CH₂NH} = 6.0 Hz; J_{CH₂CH₂} = 6.3 Hz); 1.436-1.371 (m(tt and tq); 4H; butyl-CH₂-CH₂); 1.311 (s; 9H; tert.-butyl-CH₃); 0.896 (t; 3H; butyl-CH₃; J_{CH₂CH₃} = 6.9 Hz) ppm.

Example 15

After recrystallization from diethyl ether, N-butyl-N'-decylurea was obtained in a yield of 96% of theory as described in Example 1, but using 4.47 g of decyl bromide (20 mmol) as the alkylating agent.

¹H-NMR (CDCl₃; 200 MHz; delta): 5.531 (t; 2H; NH; J_{CH₂NH} = 5.1 Hz); 3.161-3.072 (m(2dt); 4H; N-CH₂; J_{CH₂NH} = 5.1 Hz); 1.522-1.256 (M; 20H; butyl- and decyl-CH₂); 0.941 (t; 3H; butyl-CH₃; J_{CH₂CH₃(B)} = 6.0 Hz); 0.896 (t; 3H; decyl-CH₃; J_{CH₂CH₃(D)} = 6.6 Hz) ppm.

Example 16

N-butyl-N'-decylurea was obtained in a yield of 95% of theory as described in Example 15, but using 3.54 g of decyl chloride (20 mmol) as the alkylating

agent. The ^1H -NMR spectrum was entirely identical with that of Example 15.

Example 17

After recrystallization from n-hexane, N,N'-di-decylurea was obtained in a yield of 97% of theory as described in Example 1, but using 4.0 g of N-decylurea (20 mmol) and 4.47 g of decyl bromide.

^1H -NMR (CDCl_3 ; 200 MHz; δ): 4.524 (t; 2H, NH, $J_{\text{CH}_2\text{NH}} = 6.0$ Hz); 3.139 (dt; 4H, N- CH_2 ; $J_{\text{CH}_2\text{NH}} = 6.0$ Hz; $J_{\text{CH}_2\text{CH}_2} = 6.8$ Hz); 1.481 (tt; 4H, N- CH_2 - CH_2 ; $J_{\text{CH}_2\text{CH}_2} = 6.8$ Hz); 1.259 (m; 32H; decyl- CH_2); 0.880 (t; 6H; CH_3 , $J_{\text{CH}_2\text{CH}_3} = 6.5$ Hz) ppm.

Example 18

N,N'-didecylurea was obtained in a yield of 95% of theory as described in Example 17, but using 3.54 g of decyl chloride (20 mmol) as the alkylating agent. The ^1H -NMR spectrum was entirely identical with that of Example 17.

Example 19

N'-butylpyrrolidine-N-carboxamide was obtained in a yield of 41% of theory as described in Example 1, but using 2.28 g of pyrrolidine carboxamide (20 mmol) as the urea and 2.74 g of butyl bromide (20 mmol) as the alkylating agent.

^1H -NMR (CDCl_3 ; 200 MHz; δ): 4.390 (t; 1H; NH; $J_{\text{CH}_2\text{NH}} = 5.8$ Hz); 3.340 (t; 4H; N- CH_2 ; $J_{12} = 6.7$ Hz); 3.222 (dt; 2H; HN- CH_2 ; $J_{\text{CH}_2\text{NH}} = 5.8$ Hz; $J_{\text{CH}_2\text{CH}_2} = 7.0$ Hz); 1.893 (tt; 4H; pyrrolidine- CH_2 - CH_2 ; $J_{12} = 6.7$ Hz; $J_{23} = 3.5$ Hz); 1.536-1.288 (m(dt and tq); 4H; butyl- CH_2 - CH_2); 0.921 (t; 3H; CH_3 ; $J_{\text{CH}_2\text{CH}_3} = 7.1$ Hz) ppm.

Example 20

N'-butylpyrrolidine-N-carboxamide was obtained in a yield of 70% of theory as described in Example 19, but using 4.5 g of KOH pellets (80 mmol) and 0.55 g of potassium carbonate (4 mmol) as the base and heating at reflux temperature for 16 hours. The ^1H -NMR spectrum was entirely identical with that of Example 19.

Example 21

N'-propylmorpholine-N-carboxamide was obtained in a yield of 60% of theory as described in Example 1, but using 2.60 g of morpholinecarboxamide (20 mmol) as the urea and 2.46 g of propyl bromide (20 mmol) as the alkylating agent.

¹H-NMR (CDCl₃; 200 MHz; delta): 4.992 (t; 1H; NH; J_{CH₂NH} = 5.8 Hz); 3.634 (t; 4H; O-CH₂; J = 5.0 Hz); 3.308 (t; 4H; N-CH₂; J = 5.0 Hz); 3.132 (dt; 2H; HN-CH₂; J_{CH₂NH} = 5.8 Hz; J_{CH₂CH₂} = 7.3 Hz); 1.476 (tq; 2H; HN-CH₂-CH₂; J_{CH₂CH₂} = 7.3 Hz; J_{CH₂CH₃} = 7.3 Hz); 0.870 (t; 3H; CH₃; J_{CH₂CH₃} = 7.3 Hz) ppm.

Example 22

N'-isopropylmorpholine-N-carboxamide was obtained in a yield of 26% of theory as described in Example 21, but using 2.46 g of 2-bromopropane.

¹H-NMR (CDCl₃; 200 MHz; delta): 4.555 (d; 1H; NH; J_{CHNH} = 6.7 Hz); 3.969 (dse; 1H; HN-CH; J_{CHNH} = 6.7 Hz; J_{CHCH₃} = 6.6 Hz); 3.675 (t; 4H; O-CH₂; J = 4.9 Hz); 3.328 (t; 4H; N-CH₂; J = 4.9 Hz); 1.153 (d; 6H; CH₃; J_{CHCH₃} = 6.6 Hz) ppm.

Example 23

N'-butylmorpholine-N-carboxamide was obtained in a yield of 85% of theory as described in Example 21, but using 2.74 g of butyl bromide (20 mmol) as the alkylating agent.

¹H-NMR (CDCl₃; 200 MHz; delta): 5.413 (t; 1H; NH; J_{CH₂NH} = 6.0 Hz); 3.664 (t; 4H; O-CH₂; J = 5.0 Hz); 3.360 (t; 4H; N-CH₂; J = 5.0 Hz); 3.190 (dt; 2H; HN-CH₂; J_{CH₂NH} = 6.0 Hz; J_{CH₂CH₂} = 6.7 Hz); 1.522-1.275 (m(tt and tq); 4H; butyl-CH₂-CH₂); 0.917 (t; 3H; CH₃; J_{CH₂CH₃} = 6.7 Hz) ppm.

Example 24

After recrystallization from n-hexane, N'-decylmorpholine-N-carboxamide was obtained in a yield of 88% of theory as described in Example 21, but using 4.47 g of decylbromide (20 mmol).

¹H-NMR (CDCl₃; 200 MHz; delta): 4.787 (t; 1H; NH; J_{CH₂NH} = 5.6 Hz); 3.678 (t; 4H; O-CH₂; J = 5.0 Hz); 3.340 (t; 4H; N-CH₂; J = 5.0 Hz); 3.208 (dt; 2H; HN-CH₂; J_{CH₂NH} = 5.6 Hz; J_{CH₂CH₂} = 7.2 Hz); 1.493 (tt; 2H; HN-CH₂-CH₂; J_{CH₂CH₂} =

7.2 Hz); 1.261 (m; 14H; decyl-CH₂); 0.880 (t; 3H, CH₃, J_{CH₂CH₃} = 6.5 Hz) ppm.

Example 25

2.25 g of powdered KOH (40 mmol) were suspended under argon in 20 ml of anhydrous dimethyl sulfoxide. After 10 minutes 0.6 g of urea (10 mmol) and 2.12 g of hexyl iodide (10 mmol) were added with vigorous stirring, and the mixture was stirred for a further 30 minutes at room temperature. When the reaction was complete, the reaction mixture was poured into 150 ml of distilled water, and the resulting suspension was extracted with methylene chloride and chloroform. The organic phase was washed with water, dried over sodium sulfate and evaporated. This gave 0.33 g of N-hexylurea, ie. 26% of theory.

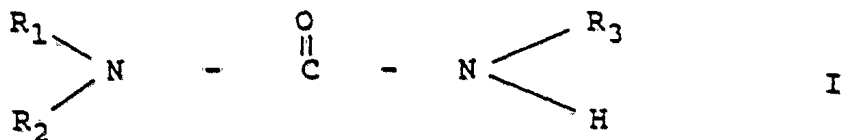
¹H-NMR (CDCl₃; 200 MHz; delta): 5.895 (t; 1H; NH; J_{CH₂NH} = 5.3 Hz); 5.359 (s; 2H, NH₂); 2.914 (dt; 2H; N-CH₂; J_{CH₂NH} = 5.3 Hz; J_{CH₂CH₂} = 6.4 Hz); 1.312-1.230 (m; 8H; hexyl-CH₂); 0.846 (t; 3H; CH₃; J = 6.5 Hz) ppm.

Example 26

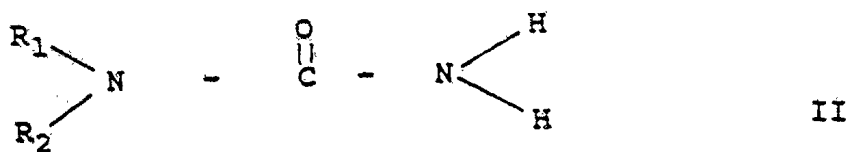
N,N'-dibutylurea was obtained in a yield of 22% of theory as described in Example 25, but using 1.16 g of butylurea (10 mmol) as the urea and 1.37 g of butyl bromide (10 mmol) as the alkylating agent. The ¹H-NMR spectrum was entirely identical with that of Example 10.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Process for the preparation of ureas of the formula



in which R_1 and R_2 independently of one another denote hydrogen, a linear, branched or cyclic alkyl group which is unsubstituted or substituted by groups inert under the conditions of the reaction, or an aralkyl group, or R_1 and R_2 , together with the nitrogen atom, denote a non-aromatic, heterocyclic ring and R_3 denotes an alkyl group which is unsubstituted or substituted by groups inert under the conditions of the reaction, the tertiary butyl group being excluded, comprising N-alkylating a urea of the formula



in which R_1 and R_2 have the abovementioned meaning in the presence of a solid base used in excess relative to the urea of formula (II) and in the presence of a phase transfer catalyst in a diluent at temperatures of 0 to 150°C with an alkylating agent of the formula



in which R_3 has the meaning indicated above and n denotes the numbers 1 or 2, X representing a halide or a sulfonic acid or bisulfate group in the event that n denotes the number 1, and X representing a sulfate group in the event that n denotes the number 2.

2. Process according to Claim 1, comprising employing a urea of the formula II in which R_1 and R_2



independently of one another denote hydrogen or an unsubstituted, linear or branched alkyl group having 2 to 18 C atoms, or R_1 and R_2 , together with the nitrogen atom, denote a pyrrolidine, piperidine or morpholine ring.

- 5 3. Process according to Claim 1 comprising employing as base a solid alkali metal hydroxide with or without the addition of 2 to 20 mol% of a solid alkali metal carbonate, relative to the alkali metal hydroxide.
- 10 4. Process according to Claim 1 comprising employing 1.5 to 8 mol of the solid base per mole of urea of the formula II.
- 15 5. Process according to Claim 1 comprising employing a quaternary ammonium salt as the phase transfer catalyst.
- 15 6. Process according to Claim 1 comprising employing an aromatic hydrocarbon as the diluent.
- 15 7. Process according to claim 6 wherein the aromatic hydrocarbon is toluene.
- 15 8. Process according to Claim 1 comprising employing dimethyl sulfoxide as the diluent and as the catalyst.
- 20 9. Process according to claim 8 wherein the pelletized or powdered solid base is suspended in dimethyl sulfoxide before the addition of the urea of formula II and the alkylating agent.
- 25 10. Process according to claim 8 wherein the reaction mixture is heated to between 0°C and 100°C.
11. Process according to Claim 1 comprising carrying out the reaction at the reflux temperature of the diluent, unless dimethyl sulfoxide is employed as the diluent.



12. Process according to Claim 1 comprising employing an alkylating agent of the formula III in which R_3 denotes a linear or branched, unsubstituted alkyl group and X denotes a chloride or bromide or a 4-toluenesulfonate, methylsulfonate or sulfate group.

13. Process according to Claim 1 comprising employing the urea of the formula II and the alkylating agent of the formula III in an equimolar ratio.

14. Process according to Claim 1 wherein the diluent is dried before use.

15. Process for the preparation of ureas of the formula I substantially as herein described with reference to any one of the Examples.

16. A urea of formula I when prepared by a process substantially as herein described with reference to any one of the Examples.

Dated this 19th day of May 1993

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By their Patent Attorney
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ABSTRACT

Process for the N-alkylation of ureas by reacting a urea with an alkylating agent in the presence of a solid base and a phase transfer catalyst in a diluent.

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