ABSTRACT

The invention provides fermentative methods for producing n-propanol. The methods of the invention involve providing a suitable carbon source, a microorganism expressing the dicarboxylic acid pathway, reducing equivalents, and at least one gene coding for an enzyme that catalyzes the conversion of propionate/propionyl-CoA into n-propanol. The methods further involve contacting the carbon source and reducing equivalents with the microorganism under conditions favorable for the production of n-propanol. Also provided are methods for producing propylene and polypropylene from the n-propanol and microorganisms suitable for use in the methods of the invention.

FIGURE 4

WE CLAIM:

1. A method for producing n-propanol comprising:
   (a) providing a suitable carbon source for fermentation by a microorganism expressing the dicarboxylic acid pathway, reducing equivalents, in the form of NAD(P)H, and at least one gene coding for an enzyme that catalyzes the conversion of propionate/propionyl-CoA into n-propanol;
   (b) contacting the carbon source and reducing equivalents in the form of NAD(P)H with the microorganism under conditions favorable for the production of n-propanol by the microorganism; whereby a fermentation broth is produced; and
   (c) recovering n-propanol from the fermentation broth.

2. The method of claim 1, wherein the microorganism has been genetically engineered to express one or more enzymes, whereby the microorganism is capable of converting propionate/propionyl-CoA to n-propanol.

3. The method of claim 2, wherein the microorganism is selected from the group consisting of: *Propionigenium* spp., *Propionispira arboris*, *Propionibacterium* spp., and *Selenomonas*.

4. The method of claim 2, wherein the enzyme is selected from the group consisting of:

   aldehyde dehydrogenases that are capable of using propionic acid as a substrate;

   aldehyde dehydrogenases that are capable of using an acyl-CoA intermediateas a substrate;

   alcohol dehydrogenases that catalyze the conversion of an aldehyde to its corresponding primary alcohol; and

   multifunctional enzymes that posses both aldehyde/alcohol dehydrogenase domains.

5. The method of claim 4, wherein the enzyme has alcohol dehydrogenase protein domain with e-value threshold below 1e-2.

6. The method of claim 4, wherein the enzyme has aldehyde dehydrogenase protein domain with e-value threshold below 1e-2.

7. The method of claim 4, wherein the aldehyde dehydrogenases are capable of using propionic acid as a substrate are selected from the group consisting of: *Mus musculus* (GenBank Accession No. AC162458.4); *Clostridium botulinum* A str. American Type Culture Collection (ATCC) No. 3502 (GenBank Accession No. AM412317.1); and *Saccharomyces cerevisiae* (GenBank Accession No. EU255273.1).

8. The method of claim 4, wherein the aldehyde dehydrogenases that are capable of using acyl-CoA intermediate as a substrate are selected from the group consisting of: *Rhodococcus opacus* (GenBank Accession No. AP011115.1); *Entamoeba dispar* (GenBank Accession No. DS548207.1); and *Lactobacillus reuteri* (GenBank Accession No. ACHG01000187.1).

9. The method of claim 4, wherein the alcohol dehydrogenases that catalyze the conversion of an aldehyde to its corresponding primary alcohol are selected from the group consisting of: *Aspergillus niger* (GenBank Accession No. AM270229.1); *Streptococcus pneumoniae* Taiwan19F-14 (GenBank Accession No. CP000921.1); and *Salmonella enterica* (GenBank Accession No. CP001127.1).

10. The method of claim 4, wherein the multifunctional enzymes that posses both aldehyde/alcohol dehydrogenase domains are selected from the group consisting of: *Lactobacillus sakei* (GenBank Accession No. CR936503.1); *Giardia intestinalis* (GenBank Accession No. U93353.1); *Shewanella amazonensis* (GenBank Accession No. CP000507.1); *Thermosynechococcus elongatus* (GenBank Accession No. BA000039.2); *Clostridium acetobutylicum* (GenBank Accession No. AE001438.3); and *Clostridium carboxidivorans* ATCC No. BAA-624T (GenBank Accesion No. ACVI01000101.1).

11. The method of claim 1, wherein the fermentation broth further comprises ethanol and/or isopropanol.

12. The method of claim 11, wherein ethanol and/or isopropanol are recovered from fermentation broth.

13. The method of claim 1, wherein the microorganism has the expression of its gene encoding for an enzyme acetate kinase (E.C. 2.7.2.1) altered so as to diminish its activity.

14. The method of any one of claims 1-13, wherein the reducing equivalents comprise NAD(P)H.

15. The method of claim 14, wherein the NAD(P)+ is reduced to NAD(P)H comprising the use of electrodes and a mediator molecule, an overpressure of H2, or a microorganism expressing a NAD+-dependent formate dehydrogenase in the presence of formate.

16. The method of claim 14, further comprising contacting the fermentation broth with electrodes and a mediator molecule.

17. The method of claim 16, wherein mediator molecules are benzyl viologen, methyl viologen, anthraquinone 2,6-disulfonic acid, neutral red, cobalt sepulchrate, 1,4 dihydroxy-2-naphthoic acid (DHNA) and flavins.

18. The method of claim 16, wherein mediator molecules are compounds present in yeast extract and Propionibacterium spp. extract.

19. The method of any one of claims 1-18, wherein the carbon source is sugarcane juice, sugarcane molasses, hydrolyzed starch, hydrolyzed ligno-cellulosic materials, glucose, sucrose, fructose, lactate, lactose, xylose or glycerol in any form or a mixture thereof.

20. A microorganism for using in the method as defined in any one of claims 1 to 19.

21 A method of claim 1 further comprising:

dehydrating the n-propanol produced by the method as defined in any one of claims 1 to 19 to produce propylene.

22. A method of claim 1 further comprising:

dehydrating in the same reactor n-propanol and isopropanol and/or ethanol produced by the method as defined in any of claims 1 to 19 to produce propylene.

23. A method of claim 1 further comprising:

polymerizing the propylene produced by the method as defined in any one of claims 21 and 22 to produce polypropylene.

Dated this 3rd April, 2012

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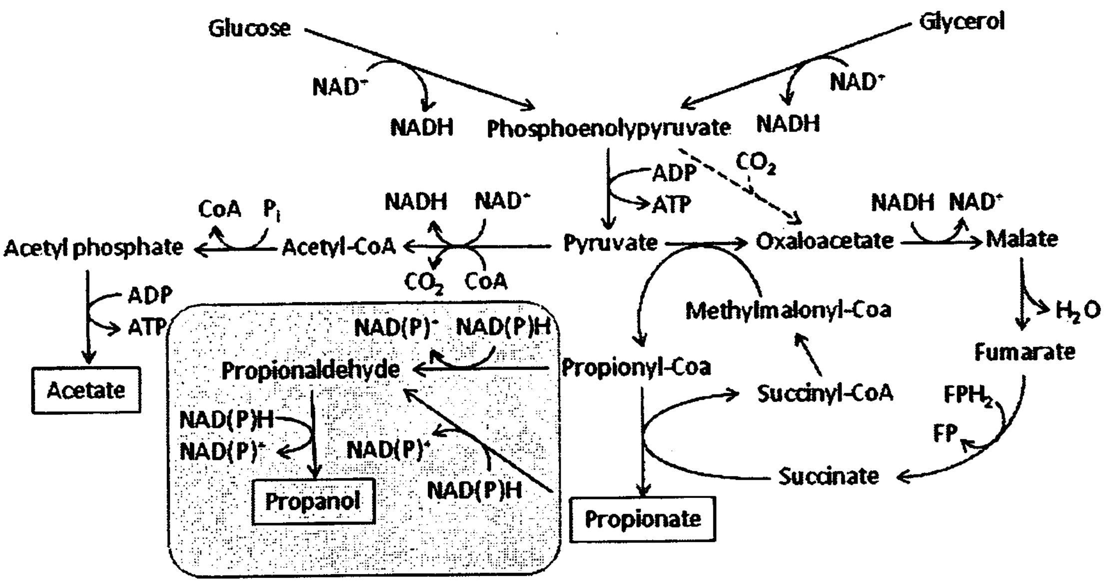

FIGURE 1

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2878DELNP12

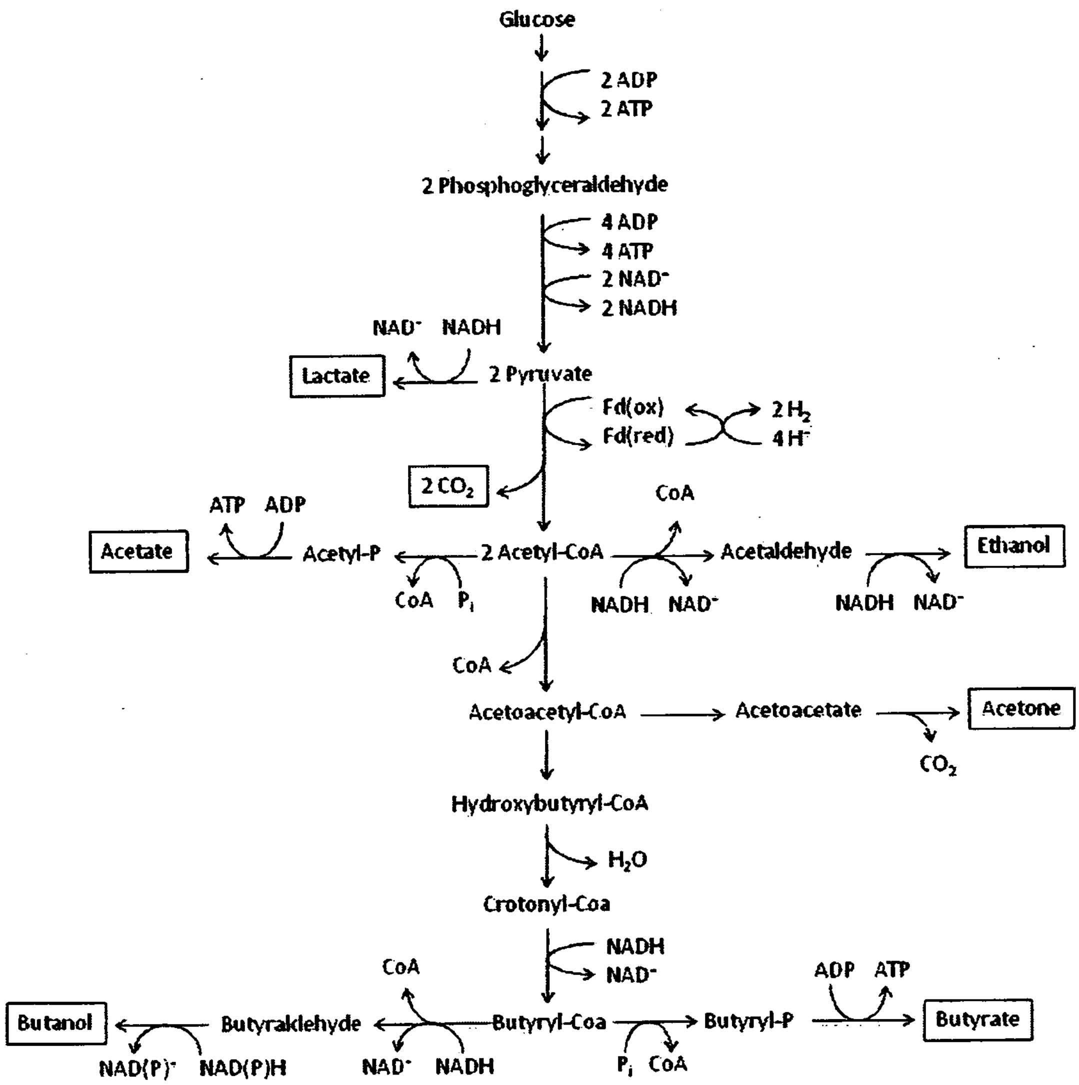

FIGURE 2

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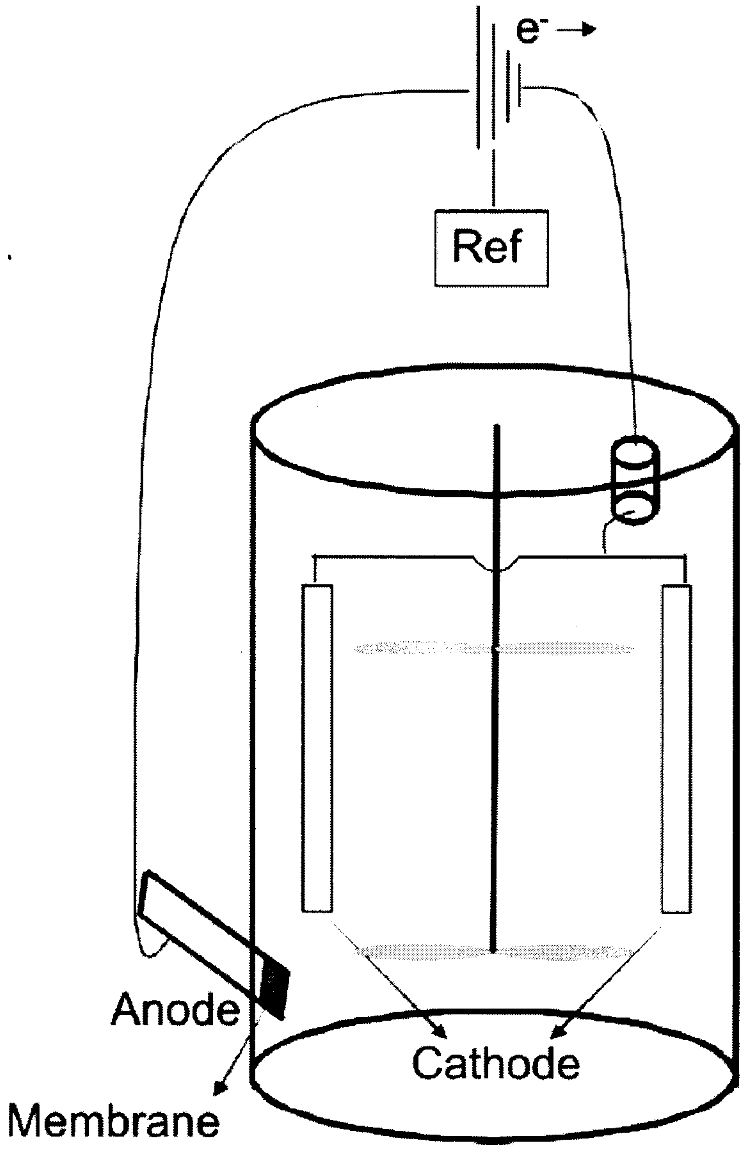

Figure 3

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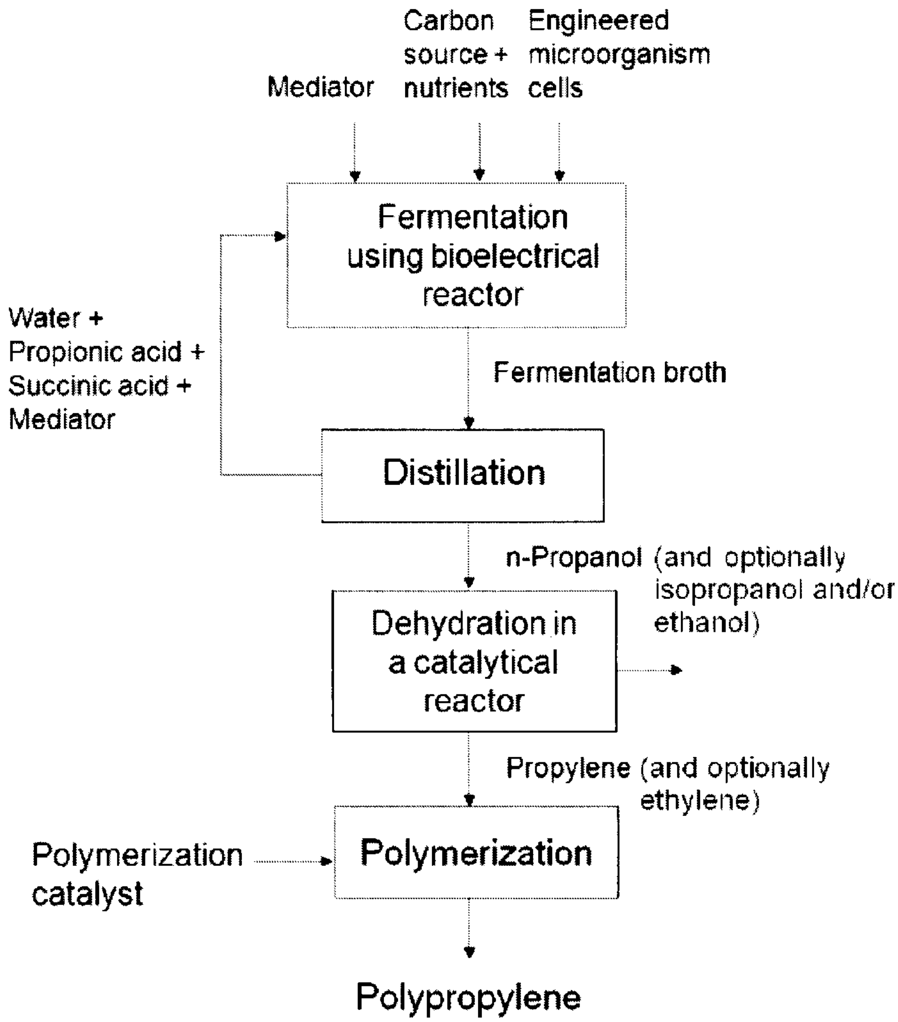

Figure 4

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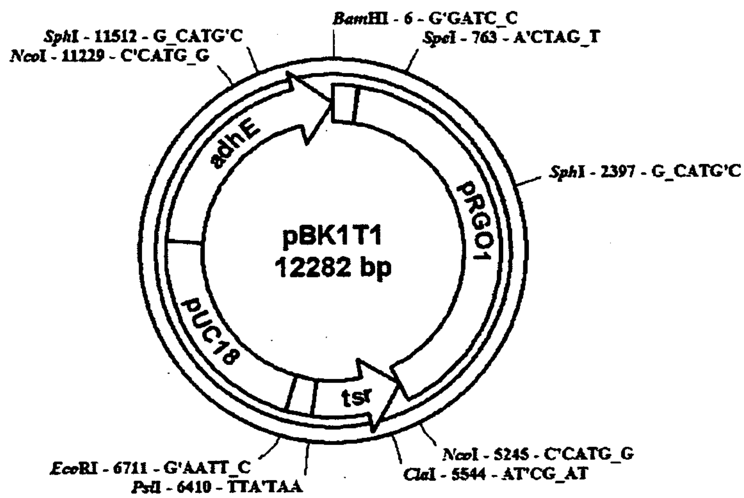

Figure 5

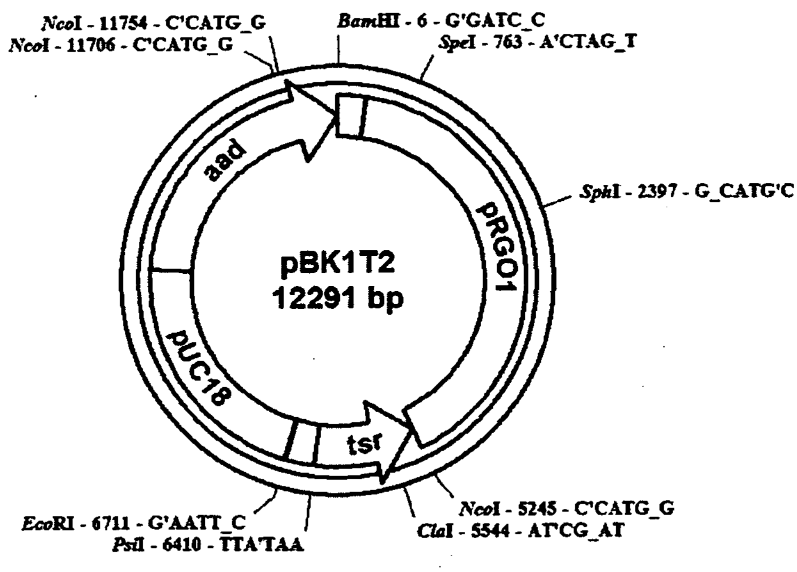

FIGURE 6

SNEHA AGARWAL
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```
   1 GATGACATCC ATGGGTGTGC CATTTCTCAC AATCCCGGGG TGCGATTGTC
  51 GCGTTTCCCA CAGGAATCGG CGCGGGGATC TGGAGGGTGC TGCGACACGC
 101 CCATATTTTG AACGATGTTC AGTGCGTCAA CCTCGACCCC AGTGCTGAAC
 151 TTGTCCGTCG CGGGTGCAAG GATTGGACCC ATGAGTCCGC GAAAGATTGG
 201 CGTTACCGAG CTCGCGCTCC GCGACGCGCA TCAGAGCCTG ATTGCAACCC
 251 GG(ATG)ACTGA GTTGGACACC ATCGCAAATC CGTCCGATCC CGCGGTGCAG
 301 CGGATCATCG ATGTCACCAA GCCGTCGCGA TCCAACATAA AGACAACGTT
 351 GATCGAGGAC GTCGAGCCCC TCATGCACAG CATCGCGGCC GGGGTGGAGT
 401 TCATCGAGGT CTACGGCAGC GACAGCAGTC CTTTTCCATC TGAGTTGCTG
 451 GATCTGTGCG GGCGGCAGAA CATACCGGTC CGCCTCATCG ACTCCTCGAT
 501 CGTCAACCAG TTGTTCAAGG GGGAGCGGAA GGCCAAGACA TTCGGCATCG
 551 CCCGCGTCCC TCGCCCGGCC AGGTTCGGCG ATATCGCGAG CCGGCGTGGG
 601 GACGTCGTCG TTCTCGACGG GGTGAAGATC GTCGGGAACA TCGGCGCGAT
 651 AGTACGCACG TCGCTCGCGC TCGGAGCGTC GGGGATCATC CTGGTCGACA
 701 GTGACATCAC CAGCATCGCG GACCGGCGTC TCCAAAGGGC CAGCCGAGGT
 751 TACGTCTTCT CCCTTCCCGT CGTTCTCTCC GGTCGCGAGG AGGCCATCGC
 801 CTTCATTCGG GACAGCGGTA TGCAGCTGAT GACGCTCAAG GCGGATGGCG
 851 ACATTTCCGT GAAGGAACTC GGGGACAATC CGGATCGGCT GGCCTTGCTG
 901 TTCGGCAGCG AAAAGGGTGG GCCTTCCGAC CTGTTCGAGG AGGCGTCTTC
 951 CGCCTCGGTT TCCATCCCCA TGATGAGCCA GACCGAGTCT CTCAACGTTT
1001 CCGTTTCCCT CGGAATCGCG CTGCACGAGA GGATCGACAG GAATCTCGCG
1051 GCCAACCGA(TAA)TCAGGCTG AGAACGACCT GATCCGCCAC TCGCGGAACT
1101 CCGGACGCCG CGTCCCCTCG GGGGCGCGGC GTCCTGCATG TCCGGGCGCA
1151 GGGGCAAGGC AGGCCTCCTA CTTATAAACG ATC
```

FIGURE 7

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ORIGINAL 2878 DELNP 12

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1 GAGTTCTAGA GTGTGCCATT TCTCACAATC CCGGGGTGCG ATTGTCGCGT
51 TTCCCACAGG AATCGGCGCG GGGATCTGGA GGGTGCTGCG ACACGCCCAT
101 ATTTTGAACG ATGTTCAGTG CGTCAACCTC GACCCCAGTG CTGAACTTGT
151 CCGTCGCGGG TGCAAGGATT GGACCCATGA GTCCGCGAAA GATTGGCGTT
201 ACCGAGCTCG CGCTCCGCGA CGCGCATCAG AGCCTGATTG CAACCCGG(AT
251 G)AAGGTCACC AACGTCGAGG AGCTGATGAA GAAGATGCAG GAGGTGCAGA
301 ACGCCCAGAA GAAGTTCGGC TCCTTCACCC AGGAGCAGGT CGACGAGATC
351 TTCCGCCAGG CCGCGCTGGC CGCGAACTCG GCCCGCATCG ACCTGGCCAA
401 GATGGCCGTC GAGGAGACCA AGATGGGCAT CGTCGAGGAC AAGGTGATCA
451 AGAACCACTT CGTCGCCGAG TACATCTACA ACAAGTACAA GAACGAGAAG
501 ACCTGCGGCA TCCTGGAGGA GGACGAGGGC TTCGGCATGG TCAAGATCGC
551 CGAGCCGGTC GGCGTCATCG CCGCGGTCAT CCCGACCACC AACCCCACCT
601 CCACCGCCAT CTTCAAGGCC CTCCTGGCCC TCAAGACCCG CAACGGCATC
651 ATCTTCTCCC CGCACCCGCG CGCCAAGAAG TGCACCATCG CCGCGGCCAA
701 GCTGGTGCTC GACGCCGCGG TGAAGGCCGG CGCCCCGAAG GGCATCATCG
751 GCTGGATCGA CGAGCCCTCC ATCGAGCTGT CGCAGATCGT CATGAAGGAG
801 GCCGACATCA TCCTGGCCAC CGGCGGCCCC GGCATGGTGA AGGCCGCGTA
851 CTCGTCCGGC AAGCCCGCCA TCGGCGTCGG CCCCGGCAAC ACCCCCGCCC
901 TGATCGACGA GTCCGCCGAC ATCAAGATGG CCGTCAACTC CATCCTGCTG
951 TCCAAGACCT TCGACAACGG CATGATCTGC GCCTCCGAGC AGTCGGTGGT
1001 CGTCGTCGAC TCGATCTACG AGGAGGTGAA GAAGGAGTTC GCCCACCGCG
1051 GCGCCTACAT CCTGTCCAAG GACGAGACCA CCAAGGTCGG CAAGATCCTC
1101 CTGGTCAACG GCACCCTGAA CGCCGGCATC GTCGGCCAGT CGGCCTACAA
1151 GATCGCCGAG ATGGCCGGCG TGAAGGTCCC GGAGGACGCC AAGGTGCTCA
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1251 AAGCTCTCGC CCGTCCTGGC CATGTACCGC GCCAAGAACT TCGACGAGGC
1301 CCTGCTCAAG GCCGGCCGCC TCGTCGAGCT GGGCGGGATG GGCCACACCT
1351 CGGTCCTGTA CGTCAACGCC ATCACCGAGA AGGTGAAGGT GGAGAAGTTC
1401 CGCGAGACCA TGAAGACCGG CCGCACCCTG ATCAACATGC CCTCCGCCCA
1451 GGGCGCCATC GGCGACATCT ACAACTTCAA GCTCGCCCCC TCCCTGACCC
1501 TCGGCTGCGG CTCCTGGGGC GGCAACTCCG TGTCCGAGAA CGTGGGCCCG
1551 AAGCACCTGC TGAACATCAA GTCGGTGGCC GAGCGCCGCG AGAACATGCT
1601 GTGGTTCCGC GTGCCGGAGA AGGTCTACTT CAAGTACGGC TCCCTCGGCG
1651 TCGCCCTCAA GGAGCTCGAC ATCCTCGACA AGAAGAAGGT GTTCATCGTG

FIGURE 8 (Sheet 1 of 2)

SNEHA AGARWAL
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1701 ACCGACAAGG TGCTGTACCA GCTGGGCTAC ATCGACCGCG TCACCAAGAT

1751 CCTCGAGGAG CTCAAGATCT CCTACAAGAT CTTCACCGAC GTCGAGCCCG

1801 ACCCCACCCT GGCCACCGCC AAGAAGGGCG CCGAGGAGCT GCTGTCCTTC

1851 AACCCCGACA CCATCATCGC CGTGGGCGGG GGCTCCGCCA TGGACGCCGC

1901 CAAGATCATG TGGGTGATGT ACGAGCACCC GGAGGTGCGC TTCGAGGACC

1951 TCGCCATGCG CTTCATGGAC ATCCGCAAGC GCGTCTACAC CTTCCCGAAG

2001 ATGGGCGAGA AGGCCATGAT GATCTCGGTG GCCACCTCGG CCGGCACCGG

2051 CTCGGAGGTC ACCCCCTTCG CCGTCATCAC CGACGAGAAG ACCGGCGCCA

2101 AGTACCCCCT GGCCGACTAC GAGCTGACCC CGAACATGGC CATCATCGAC

2151 GCCGAGCTCA TGATGGGCAT GCCGAAGGGC CTCACCGCCG CGTCCGGCAT

2201 CGACGCCCTG ACCCACGCGA TCGAGGCCTA CGTGTCGATC ATGGCCTCCG

2251 AGTACACCAA CGGCCTGGCC CTGGAGGCCA TCCGCCTGAT CTTCAAGTAC

2301 CTCCCGATCG CCTACTCGGA GGGCACCACC TCCATCAAGG CCCGCGAGAA

2351 GATGGCCCAC GCCTCGACCA TCGCCGGCAT GGCCTTCGCC AACGCCTTCC

2401 TCGGCGTCTG CCACTCGATG GCCCACAAGC TGGGCTCGAC CCACCACGTC

2451 CCCCACGGCA TCGCCAACGC CCTGCTGATC AACGAGGTGA TCAAGTTCAA

2501 CGCCGTCGAG AACCCCCGCA AGCAGGCCGC CTTCCCGCAG TACAAGTACC

2551 CGAACATCAA GAAGCGCTAC GCCCGCATCG CCGACTACCT CAACCTCGGC

2601 GGCTCGACCG ACGACGAGAA GGTCCAGCTC CTGATCAACG CCATCGACGA

2651 GCTCAAGGCC AAGATCAACA TCCCGGAGTC CATCAAGGAG GCCGGCGTCA

2701 CCGAGGAGAA GTTCTACGCC ACCCTCGACA AGATGTCGGA GCTCGCCTTC

2751 GACGACCAGT GCACCGGCGC CAACCCGCGC TACCCGCTCA TCTCCGAGAT

2801 CAAGCAGATG TACGTGAACG CCTTC(TGA)**TG ATCAGGCTGA GAACGACCTG**

2851 **ATCCGCCACT CGCGGAACTC CGGACGCCGC GTCCCCTCGG GGGCGCGGCG**

2901 **TCCTGCATGT CCGGGCGCAG GGGCAAGGCA** GGCCTCCTAC AAGCTTGAGT

FIGURE 8 (Sheet 2 of 2)

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```
   1 GAGTTCTAGA GTGTGCCATT TCTCACAATC CCGGGGTGCG ATTGTCGCGT
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 551 CGAGCCCATC GGCGTCGTCG CCGCGATCAT CCCCGTCACC AACCCGACCT
 601 CCACCACGAT CTTCAAGTCG CTGATCTCGC TCAAGACCCG CAACGGCATC
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 701 GACCATCCTG GACGCCGCGG TCAAGTCGGG CGCCCCCGAG AACATCATCG
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FIGURE 9 (Sheet 1 of 2)

SNEHA AGARWAL
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FIGURE 9 (Sheet 2 of 2)

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Patent Agent No. 1969

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 351 CTGCGCCAGA CAGCTAAGAA TGCACGAGGT GTGTCTCCGA TTCTCAGGAA
 401 ACGCTCAGCA TTTTCCGAGA CGTTCGGCGC ACGCACACAC CCCCACAAGA
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1001 CTTGGCCTGG ACGATTGAGT ACACCGACCC CGCCGTCAAA GCACTGCGCA
1051 AACTCGACCG AGCCCAGGCC CGCCGCATCA CCGCCTACAT ACGTGAGCTC
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1301 ACCACCCGCC CCACCGAGCA CTGAGGATGT CAACTCGCCC GAGCCGGCCT
1351 GCCGGCCGTC TTACGGGTTG TCTTGGCGGG CGGGGTGTCT TTGCCCTGGC
1401 CCAGCAGCCC CACGATCTCC CGCAGCGTGT CGGCGGTGGC GGCGTCCCGG
1451 GCCGCCTGAC GCTCCGCCTC CGCCCTGGCC TGCTCGGCTG CCTGCGCCCG
1501 ATCCTCCGCG GCGGCGGCCT GCTCCCTCGC CTCGGCCAGC TCGCCGGTCA
1551 GGGCCTCGAC CCGGGCCTGC ACCTGCCCCA GGCGCGCCTC CGCCTCCTGC
1601 TGCACCTGCT CGGCCCGGGC CTCCGCCTGG TCCCGGGCCG CCTCGGCCTC
1651 GGCCCGGTGC TGATCCGCCA GGGCCGCCTC GGCCACCGCT TCGGCCTGCC
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FIGURE 10 (Sheet 1 of 7)

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1701 CATCCACCGC CTGCTCGGCC CGAGCCCCGA ACTCCTCGCG GGCCGCATCA
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1951 TGACCCATTC GACTCCATGA CCCACCCTCC CATTCTGTAC CCTGTACCTG
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2051 CCCTCACACT CCCCCTGCAC GGGGCCCGCC CCCTGCACCC CCGCTGCCGC
2101 GCCCGCTCCT GCGTCGCGGC CTTGCCCCTG CCCAACGCCG GGCCGGCGGG
2151 CAGCCCACCA GAGGCTCTGT GAGACGTCGG CGCCCCCGTC CACCTACCCT
2201 AAAGACCAAC CGGCCGTGGA AACGTCTGTG AGGAGCCTTG TAGGAGTTCC
2251 CAGGACAAGC CAGCAAGGCC GGGCCTGACG GCCCGGAAAG GAAGTCGCTG
2301 CGCTCCTACG AAGAAGCCCC TCTGGGGACC CCCAGACCCC GGAACTATCT
2351 GATTTGGTTT AGCGGCGTAC TTCCGTCATA CCGGAATTTA TGGCATGCTG
2401 TGGTCATGGC GACGACGACG GTCGATGAGC AGTGGGAGCA GGTGTGGCTG
2451 CCCCGCTGGC CCCTGGCCTC CGACGACCTG GCAGCGGGCA TCTACCGGAT
2501 GGCCCGCCCC TCGGCGCTGG GGGTCCGATA CATCGAGGTC AACCCCCAAG
2551 CCATCAGCAA CCTCCTCGTG GTCGACTGCG ACCACCCCGA CGCTGCCATG
2601 CGCGCCGTCT GGGACCGCCA CGACTGGCTG CCCAACGCCA TCGTCGAGAA
2651 CCCCGACAAC GGCCACGCCC ACGCCGTGTG GGCCCTGGAA GCAGCCATCC
2701 CGCGCACCGA GTACGCCCAC CGCAAGCCCA TCGCCTACGC CGCCGCCGTC
2751 ACCGAGGGCC TGCGCCGATC CGTCGACGGA GACGCCTCCT ACGCCGGCCT
2801 GATCACCAAG AACCCCGAAC ACCCCGCCTG GAACACCACC TGGTGCACCG
2851 ACCACCTCTA CCGGCTGGCC GAGCTCGACA CCCACCTGGA TGCCGCCGGC
2901 CTCATGCCCG CCCCCTCCTG GCGACGCACC CGCCGGCGCA ACCCCGTCGG
2951 CCTGGGCCGC AACTGCGCCA TCTTCGAGAC CGCCCGCACC TGGGCCTACC
3001 GCGACGCCCG CCGCATCCGA CAACGCCACG AATACCCGAC CGCCGAGGAC
3051 TCGGCCGACC TGCACGCCGT CATCGCCTCC ACCGTCGAGG CGCTCAACGC
3101 CGGCTACAGC GAACCCCTGC CGGCCCGCGA GGCCGCCGGC ATCGCCGCCA
3151 GCATCCACCG ATGGATCACC CACCGTTTCT ACGGCTGGAT CGACTCCCAC
3201 ACCGTCAACG AGGCCACTTT CTCCACCATC CAGAGCTACA GAGGACACAA
3251 GGGAGCCGGC AAGGCTCGTC CTCGTGCCCG CCGTGCTGCT TCTATCACCG
3301 ATTGGGAGGC ATGATGGCTG ACGTCCAGCA CCGCGTGAAG CGTCGGGGCA
3351 CGGCCCGCGA GGCCGCAGAA CGTGTAGGGG CCTCCATCCG AACCGCCCAG
```

FIGURE 10 (Sheet 2 of 7)

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Patent Agent No. 1969

ORIGINAL 2878 DELNP 12

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3401 CGGTGGACCT CCATCCCCCG TGAGGAATGG ATCACTCAGA AGGCCGTCGA
3451 GCGTGAGGAG ATCCGGGCCT ACAAGTACGA CGAGGGGCAC ACGTGGGGCG
3501 AGACCTCGCG CCACTTCGGG ATCGCGAAGA CCACCGCCCA GGAGCGGGCC
3551 CGGCGGGCTC GAAGGGAGCG GGCGGCCGAA GCGGAGAAGG CTGCCGAGGA
3601 GGCCGAGGCC GCGCTGCGTC CGACACTCTT CGAGGGCCAG GAGCAAGGTT
3651 CTGCATGAGC AACCCCGAGT CCTCGGGTAG ACCGTCTGGC CCGACGTTAA
3701 GCATGGCTGA AGCGGCCCGT GCCTGTGGGG TTTCAGTGTC CACGGTGAGG
3751 CGTCACCGTG ATGCCCTGGT GGCCCACGGT GCTACCCGTC ATGACGCGTC
3801 ATGGGTGATA CCCCTATCAG CGTTGATTTC ATGCGGTTTG ATGCCCCGGG
3851 TGACACCCCC TGATGCCCCG TCACCCAATA ACGTGGCGCC TGCCATGACG
3901 TCCCACGGTG ACGCCCCCCT GACGGGGGAA GTCCAAGAGC TGCGCGAGCG
3951 ACTGGCCAAC GCTGAGCATC GAGCCGAGCT AGCCGAAGCC ATCGCGGCCG
4001 AGCGACAACA CACGATCGAC GCCCAGCGCA TCGCCTTACG GGCCTTAGAA
4051 CCCGGCTCGA CCCATAACAG CCCGGCAACC GATGAGCCGG CTACCGCTCG
4101 CGAGCAACCT CCCGGTCCAG AACCCAGCGA CTCCAGGCCA CACCGCCGGA
4151 GTTGGTGGCG TCGGCTGACT GGTGGCGCCT GACCGGCCCC GGTCGTCTTC
4201 GAGGGGAACC TCTCGCCTGC GAGAGGACAC AGCAGCCGGC TGTGCTGGTA
4251 GGGCATCCCA GCACGACACC CCTCTGACGC GAGAAGTTCA AGGACTACGC
4301 GAATTGCTGA CTACCGCCGA GCGGCAGCAC ACGATCGAGA TGCTCAACGA
4351 ACCGCACTAC GCGGCCTTAG AAGGCCCCAA GGCACGCTCA CCTACCACGT
4401 GGATCACCAC CGATCGGCGC CGACAGCTAT GGACCCCATC GCAAGATCAA
4451 AACCCCTGAG CAGCCATCGC ACCGAGCGCC CGGCACGCCG GAAGAAGCTC
4501 CGACGCCCCT GCTGTCCGGA CACGGCCTAA CGCGTCCAGA CCAGAACCAG
4551 TGCTCCGATC TAAACCGAAG GCCCTTCATG TGAGAGCATA GTCGTGACGT
4601 CGGCACAGTA GTCGTGCCCG GCGGGGGTAA CGCTACACAA CGCTTAAAAA
4651 GCATCGGAGC AAGCTAACAC AGGGGGACTG ATGAACAAAA CACACAAAAT
4701 GGCGACGCTG GTAATTGCCG CGATCTTGGC CGCCGGAATG ACCGCACCAA
4751 CTGCCTATGC AGATTCTCCT GGAAACACCA GAATTACAGC CAGCGAGCAA
4801 AGCGTCCTTA CCCAGATACT CGGCCACAAA CCTACACAAA CTGAATATAA
4851 CCGATACGTT GAGACTTACG GAAGCGTACC GACCGAAGCA GACATCAACG
4901 CATATATAGA AGCGTCTGAA TCTGAGGGAT CATCAAGTCA AACGGCTGCT
4951 CACGATGACT CGACATCACC CGGCACGAGT ACCGAAATCT ACACGCAGGC
5001 AGCCCCTGCC AGGTTCTCAA TGTTTTTCCT GTCCGGAACT TGGATCACTA
5051 GGAGTGGTGT AGTATCGCTC TCCTTGAAGC CAAGGAAGGG TGGTATTGGC
```

FIGURE 10 (Sheet 3 of 7)

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5101 AACGAGGGGG ACGAGCGTAC CTGGAAGACT GTATACGACA AATTCCATAA
5151 CGCTGGGCAA TGGACACGAT ACAAGAACAA CGGCGTAGAC GCCAGCATGA
5201 AAAAGCAGTA CATGTGCCAC TTCAAGTACG GGATGGTGAA GACGCCATGG
5251 GTGTGCCATT TCTCACAATC CCGGGGTGCG ATTGTCGCGT TTCCCACAGG
5301 AATCGGCGCG GGGATCTGGA GGGTGCTGCG ACACGCCCAT ATTTTGAACG
5351 ATGTTCAGTG CGTCAACCTC GACCCCAGTG CTGAACTTGT CCGTCGCGGG
5401 TGCAAGGATT GGACCCATGA GTCCGCGAAA GATTGGCGTT ACCGAGCTCG
5451 CGCTCCGCGA CGCGCATCAG AGCCTGATTG CAACCCGGAT GACTGAGTTG
5501 GACACCATCG CAAATCCGTC CGATCCCGCG GTGCAGCGGA TCATCGATGT
5551 CACCAAGCCG TCGCGATCCA ACATAAAGAC AACGTTGATC GAGGACGTCG
5601 AGCCCCTCAT GCACAGCATC GCGGCCGGGG TGGAGTTCAT CGAGGTCTAC
5651 GGCAGCGACA GCAGTCCTTT TCCATCTGAG TTGCTGGATC TGTGCGGGCG
5701 GCAGAACATA CCGGTCCGCC TCATCGACTC CTCGATCGTC AACCAGTTGT
5751 TCAAGGGGGA GCGGAAGGCC AAGACATTCG GCATCGCCCG CGTCCCTCGC
5801 CCGGCCAGGT TCGGCGATAT CGCGAGCCGG CGTGGGGACG TCGTCGTTCT
5851 CGACGGGGTG AAGATCGTCG GGAACATCGG CGCGATAGTA CGCACGTCGC
5901 TCGCGCTCGG AGCGTCGGGG ATCATCCTGG TCGACAGTGA CATCACCAGC
5951 ATCGCGGACC GGCGTCTCCA AAGGGCCAGC CGAGGTTACG TCTTCTCCCT
6001 TCCCGTCGTT CTCTCCGGTC GCGAGGAGGC CATCGCCTTC ATTCGGGACA
6051 GCGGTATGCA GCTGATGACG CTCAAGGCGG ATGGCGACAT TTCCGTGAAG
6101 GAACTCGGGG ACAATCCGGA TCGGCTGGCC TTGCTGTTCG GCAGCGAAAA
6151 GGGTGGGCCT TCCGACCTGT TCGAGGAGGC GTCTTCCGCC TCGGTTTCCA
6201 TCCCCATGAT GAGCCAGACC GAGTCTCTCA ACGTTTCCGT TTCCCTCGGA
6251 ATCGCGCTGC ACGAGAGGAT CGACAGGAAT CTCGCGGCCA ACCGATAATC
6301 AGGCTGAGAA CGACCTGATC CGCCACTCGC GGAACTCCGG ACGCCGCGTC
6351 CCCTCGGGGG CGCGGCGTCC TGCATGTCCG GGCGCAGGGG CAAGGCAGGC
6401 CTCCTACTTA TAATTGTCCC ATACGCGTCA TACTGGTTAG TCGCTGGAGA
6451 TCCAGACGTT TGGGACTTCT ATCGTTCTTT ATGGTGGATT CCAGTGGCTT
6501 TTCTAGGAAT AGTTTCAATA GTACTGATGG CTAGCAGTAG AGGTTGGGGA
6551 CGACGTCTCG GCGACTCCGG AGAACACCAA GTCAGGGTCT CATGAGTGTG
6601 CGATAGCTTG AGCTGTCTAC CAATCTGGAT ATAGCTATAT CGGTCGTTTG
6651 TGTCTGATTC GCCAGTGAGC CAACGGCGGG GGCGACACGC GGTGGCGAAA
6701 CCCCCTGGCA GAATTCGTAA TCATGGTCAT AGCTGTTTCC TGTGTGAAAT
6751 TGTTATCCGC TCACAATTCC ACACAACATA CGAGCCGGAA GCATAAAGTG

FIGURE 10 (Sheet 4 of 7)

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```
6801 TAAAGCCTGG GGTGCCTAAT GAGTGAGCTA ACTCACATTA ATTGCGTTGC
6851 GCTCACTGCC CGCTTTCCAG TCGGGAAACC TGTCGTGCCA GCTGCATTAA
6901 TGAATCGGCC AACGCGCGGG GAGAGGCGGT TTGCGTATTG GGCGCTCTTC
6951 CGCTTCCTCG CTCACTGACT CGCTGCGCTC GGTCGTTCGG CTGCGGCGAG
7001 CGGTATCAGC TCACTCAAAG GCGGTAATAC GGTTATCCAC AGAATCAGGG
7051 GATAACGCAG GAAAGAACAT GTGAGCAAAA GGCCAGCAAA AGGCCAGGAA
7101 CCGTAAAAAG GCCGCGTTGC TGGCGTTTTT CCATAGGCTC CGCCCCCCTG
7151 ACGAGCATCA CAAAAATCGA CGCTCAAGTC AGAGGTGGCG AAACCCGACA
7201 GGACTATAAA GATACCAGGC GTTTCCCCCT GGAAGCTCCC TCGTGCGCTC
7251 TCCTGTTCCG ACCCTGCCGC TTACCGGATA CCTGTCCGCC TTTCTCCCTT
7301 CGGGAAGCGT GGCGCTTTCT CAAAGCTCAC GCTGTAGGTA TCTCAGTTCG
7351 GTGTAGGTCG TTCGCTCCAA GCTGGGCTGT GTGCACGAAC CCCCCGTTCA
7401 GCCCGACCGC TGCGCCTTAT CCGGTAACTA TCGTCTTGAG TCCAACCCGG
7451 TAAGACACGA CTTATCGCCA CTGGCAGCAG CCACTGGTAA CAGGATTAGC
7501 AGAGCGAGGT ATGTAGGCGG TGCTACAGAG TTCTTGAAGT GGTGGCCTAA
7551 CTACGGCTAC ACTAGAAGAA CAGTATTTGG TATCTGCGCT CTGCTGAAGC
7601 CAGTTACCTT CGGAAAAAGA GTTGGTAGCT CTTGATCCGG CAAACAAACC
7651 ACCGCTGGTA GCGGTGGTTT TTTTGTTTGC AAGCAGCAGA TTACGCGCAG
7701 AAAAAAAGGA TCTCAAGAAG ATCCTTTGAT CTTTTCTACG GGGTCTGACG
7751 CTCAGTGGAA CGAAAACTCA CGTTAAGGGA TTTTGGTCAT GAGATTATCA
7801 AAAAGGATCT TCACCTAGAT CCTTTTAAAT TAAAAATGAA GTTTTAAATC
7851 AATCTAAAGT ATATATGAGT AAACTTGGTC TGACAGTTAC CAATGCTTAA
7901 TCAGTGAGGC ACCTATCTCA GCGATCTGTC TATTTCGTTC ATCCATAGTT
7951 GCCTGACTCC CCGTCGTGTA GATAACTACG ATACGGGAGG GCTTACCATC
8001 TGGCCCCAGT GCTGCAATGA TACCGCGAGA CCCACGCTCA CCGGCTCCAG
8051 ATTTATCAGC AATAAACCAG CCAGCCGGAA GGGCCGAGCG CAGAAGTGGT
8101 CCTGCAACTT TATCCGCCTC CATCCAGTCT ATTAATTGTT GCCGGGAAGC
8151 TAGAGTAAGT AGTTCGCCAG TTAATAGTTT GCGCAACGTT GTTGCCATTG
8201 CTACAGGCAT CGTGGTGTCA CGCTCGTCGT TTGGTATGGC TTCATTCAGC
8251 TCCGGTTCCC AACGATCAAG GCGAGTTACA TGATCCCCCA TGTTGTGCAA
8301 AAAAGCGGTT AGCTCCTTCG GTCCTCCGAT CGTTGTCAGA AGTAAGTTGG
8351 CCGCAGTGTT ATCACTCATG GTTATGGCAG CACTGCATAA TTCTCTTACT
8401 GTCATGCCAT CCGTAAGATG CTTTTCTGTG ACTGGTGAGT ACTCAACCAA
8451 GTCATTCTGA GAATAGTGTA TGCGGCGACC GAGTTGCTCT TGCCCGGCGT
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FIGURE 10 (Sheet 5 of 7)

SNEHA AGARWAL
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8501 CAATACGGGA TAATACCGCG CCACATAGCA GAACTTTAAA AGTGCTCATC
8551 ATTGGAAAAC GTTCTTCGGG GCGAAAACTC TCAAGGATCT TACCGCTGTT
8601 GAGATCCAGT TCGATGTAAC CCACTCGTGC ACCCAACTGA TCTTCAGCAT
8651 CTTTTACTTT CACCAGCGTT TCTGGGTGAG CAAAAACAGG AAGGCAAAAT
8701 GCCGCAAAAA AGGGAATAAG GGCGACACGG AAATGTTGAA TACTCATACT
8751 CTTCCTTTTT CAATATTATT GAAGCATTTA TCAGGGTTAT TGTCTCATGA
8801 GCGGATACAT ATTTGAATGT ATTTAGAAAA ATAAACAAAT AGGGGTTCCG
8851 CGCACATTTC CCCGAAAAGT GCCACCTGAC GTCTAAGAAA CCATTATTAT
8901 CATGACATTA ACCTATAAAA ATAGGCGTAT CACGAGGCCC TTTCGTCTCG
8951 CGCGTTTCGG TGATGACGGT GAAAACCTCT GACACATGCA GCTCCCGGAG
9001 ACGGTCACAG CTTGTCTGTA AGCGGATGCC GGGAGCAGAC AAGCCCGTCA
9051 GGGCGCGTCA GCGGGTGTTG GCGGGTGTCG GGGCTGGCTT AACTATGCGG
9101 CATCAGAGCA GATTGTACTG AGAGTGCACC ATATGCGGTG TGAAATACCG
9151 CACAGATGCG TAAGGAGAAA ATACCGCATC AGGCGCCATT CGCCATTCAG
9201 GCTGCGCAAC TGTTGGGAAG GGCGATCGGT GCGGGCCTCT TCGCTATTAC
9251 GCCAGCTGGC GAAAGGGGGA TGTGCTGCAA GGCGATTAAG TTGGGTAACG
9301 CCAGGGTTTT CCCAGTCACG ACGTTGTAAA ACGACGGCCA GTGCCACTAG
9351 AGTGTGCCAT TTCTCACAAT CCCGGGGTGC GATTGTCGCG TTTCCCACAG
9401 GAATCGGCGC GGGGATCTGG AGGGTGCTGC GACACGCCCA TATTTTGAAC
9451 GATGTTCAGT GCGTCAACCT CGACCCCAGT GCTGAACTTG TCCGTCGCGG
9501 GTGCAAGGAT TGGACCCATG AGTCCGCGAA AGATTGGCGT TACCGAGCTC
9551 GCGCTCCGCG ACGCGCATCA GAGCCTGATT GCAACCCGGA TGAAGGTCAC
9601 CAACGTCGAG GAGCTGATGA AGAAGATGCA GGAGGTGCAG AACGCCCAGA
9651 AGAAGTTCGG CTCCTTCACC CAGGAGCAGG TCGACGAGAT CTTCCGCCAG
9701 GCCGCGCTGG CCGCGAACTC GGCCCGCATC GACCTGGCCA AGATGGCCGT
9751 CGAGGAGACC AAGATGGGCA TCGTCGAGGA CAAGGTGATC AAGAACCACT
9801 TCGTCGCCGA GTACATCTAC AACAAGTACA AGAACGAGAA GACCTGCGGC
9851 ATCCTGGAGG AGGACGAGGG CTTCGGCATG GTCAAGATCG CCGAGCCGGT
9901 CGGCGTCATC GCCGCGGTCA TCCCGACCAC CAACCCCACC TCCACCGCCA
9951 TCTTCAAGGC CCTCCTGGCC CTCAAGACCC GCAACGGCAT CATCTTCTCC
10001 CCGCACCCGC GCGCCAAGAA GTGCACCATC GCCGCGGCCA AGCTGGTGCT
10051 CGACGCCGCG GTGAAGGCCG GCGCCCCGAA GGGCATCATC GGCTGGATCG
10101 ACGAGCCCTC CATCGAGCTG TCGCAGATCG TCATGAAGGA GGCCGACATC
10151 ATCCTGGCCA CCGGCGGCCC CGGCATGGTG AAGGCCGCGT ACTCGTCCGG
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FIGURE 10 (Sheet 6 of 7)

SNEHA AGARWAL
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10201 CAAGCCCGCC ATCGGCGTCG GCCCCGGCAA CACCCCCGCC CTGATCGACG
10251 AGTCCGCCGA CATCAAGATG GCCGTCAACT CCATCCTGCT GTCCAAGACC
10301 TTCGACAACG GCATGATCTG CGCCTCCGAG CAGTCGGTGG TCGTCGTCGA
10351 CTCGATCTAC GAGGAGGTGA AGAAGGAGTT CGCCCACCGC GGCGCCTACA
10401 TCCTGTCCAA GGACGAGACC ACCAAGGTCG GCAAGATCCT CCTGGTCAAC
10451 GGCACCCTGA ACGCCGGCAT CGTCGGCCAG TCGGCCTACA AGATCGCCGA
10501 GATGGCCGGC GTGAAGGTCC CGGAGGACGC CAAGGTGCTC ATCGGCGAGG
10551 TCAAGTCGGT GGAGCACTCC GAGGAGCCGT TCTCCCACGA GAAGCTCTCG
10601 CCCGTCCTGG CCATGTACCG CGCCAAGAAC TTCGACGAGG CCCTGCTCAA
10651 GGCCGGCCGC CTCGTCGAGC TGGGCGGGAT GGGCCACACC TCGGTCCTGT
10701 ACGTCAACGC CATCACCGAG AAGGTGAAGG TGGAGAAGTT CCGCGAGACC
10751 ATGAAGACCG GCCGCACCCT GATCAACATG CCCTCCGCCC AGGGCGCCAT
10801 CGGCGACATC TACAACTTCA AGCTCGCCCC CTCCCTGACC CTCGGCTGCG
10851 GCTCCTGGGG CGGCAACTCC GTGTCCGAGA ACGTGGGCCC GAAGCACCTG
10901 CTGAACATCA AGTCGGTGGC CGAGCGCCGC GAGAACATGC TGTGGTTCCG
10951 CGTGCCGGAG AAGGTCTACT TCAAGTACGG CTCCCTCGGC GTCGCCCTCA
11001 AGGAGCTCGA CATCCTCGAC AAGAAGAAGG TGTTCATCGT GACCGACAAG
11051 GTGCTGTACC AGCTGGGCTA CATCGACCGC GTCACCAAGA TCCTCGAGGA
11101 GCTCAAGATC TCCTACAAGA TCTTCACCGA CGTCGAGCCC GACCCCACCC
11151 TGGCCACCGC CAAGAAGGGC GCCGAGGAGC TGCTGTCCTT CAACCCCGAC
11201 ACCATCATCG CCGTGGGCGG GGGCTCCGCC ATGGACGCCG CCAAGATCAT
11251 GTGGGTGATG TACGAGCACC CGGAGGTGCG CTTCGAGGAC CTCGCCATGC
11301 GCTTCATGGA CATCCGCAAG CGCGTCTACA CCTTCCCGAA GATGGGCGAG
11351 AAGGCCATGA TGATCTCGGT GGCCACCTCG GCCGGCACCG GCTCGGAGGT
11401 CACCCCCTTC GCCGTCATCA CCGACGAGAA GACCGGCGCC AAGTACCCCC
11451 TGGCCGACTA CGAGCTGACC CCGAACATGG CCATCATCGA CGCCGAGCTC
11501 ATGATGGGCA TGCCGAAGGG CCTCACCGCC GCGTCCGGCA TCGACGCCCT
11551 GACCCACGCG ATCGAGGCCT ACGTGTCGAT CATGGCCTCC GAGTACACCA
11601 ACGGCCTGGC CCTGGAGGCC ATCCGCCTGA TCTTCAAGTA CCTCCCGATC
11651 GCCTACTCGG AGGGCACCAC CTCCATCAAG GCCCGCGAGA AGATGGCCCA
11701 CGCCTCGACC ATCGCCGGCA TGGCCTTCGC CAACGCCTTC CTCGGCGTCT
11751 GCCACTCGAT GGCCCACAAG CTGGGCTCGA CCCACCACGT CCCCCACGGC
11801 ATCGCCAACG CCCTGCTGAT CAACGAGGTG ATCAAGTTCA ACGCCGTCGA
11851 GAACCCCCGC AAGCAGGCCG CCTTCCCGCA GTACAAGTAC CCGAACATCA

11901 AGAAGCGCTA CGCCCGCATC GCCGACTACC TCAACCTCGG CGGCTCGACC
11951 GACGACGAGA AGGTCCAGCT CCTGATCAAC GCCATCGACG AGCTCAAGGC
12001 CAAGATCAAC ATCCCGGAGT CCATCAAGGA GGCCGGCGTC ACCGAGGAGA
12051 AGTTCTACGC CACCCTCGAC AAGATGTCGG AGCTCGCCTT CGACGACCAG
12101 TGCACCGGCG CCAACCCGCG CTACCCGCTC ATCTCCGAGA TCAAGCAGAT
12151 GTACGTGAAC GCCTTCTGAT GATCAGGCTG AGAACGACCT GATCCGCCAC
12201 TCGCGGAACT CCGGACGCCG CGTCCCCTCG GGGGCGCGGC GTCCTGCATG
12251 TCCGGGCGCA GGGGCAAGGC AGGCCTCCTA CA
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FIGURE 10 (Sheet 7 of 7)

SNEHA AGARWAL
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1 CTAGAGGATC CGGCGGAACT TCACGTCCTG GCGGTGGAGT TGGCGGGCGC
51 GTTCCAGCCG TTCCTCCAGC ACGGTGATCC GGGCCTCCAG ACGCTCACGC
101 TCACCCTGCT CCAGGTGCCG GGTCACCGTC ACCGTCCGCA CCGGCCGGGC
151 CTCGGCCTGG GCGGCCCGGC GTTCCTCACT GGCCCGCTTC CGGCAATCGT
201 CGGAACACCA CACCCGGGGC CGACCCCGCC CACCGTGGGC CTCCACCGGC
251 GCCCCGCAGT GGGGACACGC CCGCAGCGCC GACGCATCCT CATCCAAGGC
301 CATCACCGGG TCGGAATCCA TACCCGAAAC CATATCGTCC GGACGATGAA
351 CTGCGCCAGA CAGCTAAGAA TGCACGAGGT GTGTCTCCGA TTCTCAGGAA
401 ACGCTCAGCA TTTTCCGAGA CGTTCGGCGC ACGCACACAC CCCCACAAGA
451 ACCGACCCGC CCAGCATCCG CCGACACGTC GATCCGCACC CGCGATGGGC
501 TGGCCGAGGC CGACTACGAC CGCTAGTCAG CACCTGCGCT GATCTACCGT
551 CGCCCTGACC GACTCTCCCG TCGGGATTGT CGCCGGCCGC TGCCAGCATG
601 GACCTGCGGC CCCGCCCCCT CGCCCTGCAA CTCGAGGGAG GCGGGGCCGT
651 CCACCCCCCA CACCACCCCG ACACCGTGAT GCGCCCATGT CGCCTAACGG
701 GTTGCCCGAC CTCCCCGACA TCAAGAAAAC CTGACACCGT CGCCGCAAGC
751 GCTACACTGA CTACTAGTAG TCAGGAGGTG CGTGATGACC ATCGCCACAT
801 CGGTGAAACT CTCCGAAGAG ACCGGCCGCA AACTCGATGA ACTAGCCCGG
851 GCCACCGGGC GATCCAAGTC CTACTACCTG CGCGAGGCCA TCGAGGACCA
901 CATCGACCAG ATGGTCCACG ACTACGCCAT CGCCCGACTC GCCGACGACG
951 TGCGAGCCGG CCGGGCCGCC ACCTACAGCG CCGACGAAGT GGACCAGATC
1001 CTTGGCCTGG ACGATTGAGT ACACCGACCC CGCCGTCAAA GCACTGCGCA
1051 AACTCGACCG AGCCCAGGCC CGCCGCATCA CCGCCTACAT ACGTGAGCTC
1101 ACCGGCCTGG ACGATCCCCA CCAACGCGGG AAAGGCCTCA CCGGGCCCCT
1151 GGCCGGACTC TGGCGCTACC GCGTCGGGGA CTACCGGATC ATCTGCGACC
1201 TGAACGCCGA CCGCCTGGCC ATCATCGCCC TGACCATCGA GCACCGATCC
1251 CAGGCCTACC GCTGACACGC AACCCCGCAC CCTCGGCCAA GACGTCACAC
1301 ACCACCCGCC CCACCGAGCA CTGAGGATGT CAACTCGCCC GAGCCGGCCT
1351 GCCGGCCGTC TTACGGGTTG TCTTGGCGGG CGGGGTGTCT TTGCCCTGGC
1401 CCAGCAGCCC CACGATCTCC CGCAGCGTGT CGGCGGTGGC GGCGTCCCGG
1451 GCCGCCTGAC GCTCCGCCTC CGCCCTGGCC TGCTCGGCTG CCTGCGCCCG
1501 ATCCTCCGCG GCGGCGGCCT GCTCCCTCGC CTCGGCCAGC TCGCCGGTCA
1551 GGGCCTCGAC CCGGGCCTGC ACCTGCCCCA GGCGCGCCTC CGCCTCCTGC
1601 TGCACCTGCT CGGCCCGGGC CTCCGCCTGG TCCCGGGCCG CCTCGGCCTC
1651 GGCCCGGTGC TGATCCGCCA GGGCCGCCTC GGCCACCGCT TCGGCCTGCC
```

FIGURE 11 (Sheet 1 of 7)

SNEHA AGARWAL
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1701 CATCCACCGC CTGCTCGGCC CGAGCCCCGA ACTCCTCGCG GGCCGCATCA
1751 CTCGCCTGAC GCCACGCCGC CGCCCACACC AGACCCAACG GCTCCGACAG
1801 ATCCGGCGGG GCCGGCGTCT GGACCGACGC CGAGACGTCG CGCAGGAACC
1851 CCGCCGCAGC GTCGGTGGAG CACCCCGCCT CCGCCTTCAA CGACCGCACC
1901 GTCACCCGCC GACCCGCACC GCTCAACCGC GCATAGGCCG CCGCCAACCT
1951 TGACCCATTC GACTCCATGA CCCACCCTCC CATTCTGTAC CCTGTACCTG
2001 TTCCTAGGTA CGTTCCTAAT GTACCTCACC GGATGCAGAA CCCGCAACCC
2051 CCCTCACACT CCCCCTGCAC GGGGCCCGCC CCCTGCACCC CCGCTGCCGC
2101 GCCCGCTCCT GCGTCGCGGC CTTGCCCCTG CCCAACGCCG GGCCGGCGGG
2151 CAGCCCACCA GAGGCTCTGT GAGACGTCGG CGCCCCCGTC CACCTACCCT
2201 AAAGACCAAC CGGCCGTGGA AACGTCTGTG AGGAGCCTTG TAGGAGTTCC
2251 CAGGACAAGC CAGCAAGGCC GGGCCTGACG GCCCGGAAAG GAAGTCGCTG
2301 CGCTCCTACG AAGAAGCCCC TCTGGGGACC CCCAGACCCC GGAACTATCT
2351 GATTTGGTTT AGCGGCGTAC TTCCGTCATA CCGGAATTTA TGGCATGCTG
2401 TGGTCATGGC GACGACGACG GTCGATGAGC AGTGGGAGCA GGTGTGGCTG
2451 CCCCGCTGGC CCCTGGCCTC CGACGACCTG GCAGCGGGCA TCTACCGGAT
2501 GGCCCGCCCC TCGGCGCTGG GGGTCCGATA CATCGAGGTC AACCCCCAAG
2551 CCATCAGCAA CCTCCTCGTG GTCGACTGCG ACCACCCCGA CGCTGCCATG
2601 CGCGCCGTCT GGGACCGCCA CGACTGGCTG CCCAACGCCA TCGTCGAGAA
2651 CCCCGACAAC GGCCACGCCC ACGCCGTGTG GGCCCTGGAA GCAGCCATCC
2701 CGCGCACCGA GTACGCCCAC CGCAAGCCCA TCGCCTACGC CGCCGCCGTC
2751 ACCGAGGGCC TGCGCCGATC CGTCGACGGA GACGCCTCCT ACGCCGGCCT
2801 GATCACCAAG AACCCCGAAC ACCCCGCCTG GAACACCACC TGGTGCACCG
2851 ACCACCTCTA CCGGCTGGCC GAGCTCGACA CCCACCTGGA TGCCGCCGGC
2901 CTCATGCCCG CCCCCTCCTG GCGACGCACC CGCCGGCGCA ACCCCGTCGG
2951 CCTGGGCCGC AACTGCGCCA TCTTCGAGAC CGCCCGCACC TGGGCCTACC
3001 GCGACGCCCG CCGCATCCGA CAACGCCACG AATACCCGAC CGCCGAGGAC
3051 TCGGCCGACC TGCACGCCGT CATCGCCTCC ACCGTCGAGG CGCTCAACGC
3101 CGGCTACAGC GAACCCCTGC CGGCCCGCGA GGCCGCCGGC ATCGCCGCCA
3151 GCATCCACCG ATGGATCACC CACCGTTTCT ACGGCTGGAT CGACTCCCAC
3201 ACCGTCAACG AGGCCACTTT CTCCACCATC CAGAGCTACA GAGGACACAA
3251 GGGAGCCGGC AAGGCTCGTC CTCGTGCCCG CCGTGCTGCT TCTATCACCG
3301 ATTGGGAGGC ATGATGGCTG ACGTCCAGCA CCGCGTGAAG CGTCGGGGCA
3351 CGGCCCGCGA GGCCGCAGAA CGTGTAGGGG CCTCCATCCG AACCGCCCAG

FIGURE 11 (Sheet 2 of 7)

SNEHA AGARWAL
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```
3401 CGGTGGACCT CCATCCCCCG TGAGGAATGG ATCACTCAGA AGGCCGTCGA
3451 GCGTGAGGAG ATCCGGGCCT ACAAGTACGA CGAGGGGCAC ACGTGGGGCG
3501 AGACCTCGCG CCACTTCGGG ATCGCGAAGA CCACCGCCCA GGAGCGGGCC
3551 CGGCGGGCTC GAAGGGAGCG GGCGGCCGAA GCGGAGAAGG CTGCCGAGGA
3601 GGCCGAGGCC GCGCTGCGTC CGACACTCTT CGAGGGCCAG GAGCAAGGTT
3651 CTGCATGAGC AACCCCGAGT CCTCGGGTAG ACCGTCTGGC CCGACGTTAA
3701 GCATGGCTGA AGCGGCCCGT GCCTGTGGGG TTTCAGTGTC CACGGTGAGG
3751 CGTCACCGTG ATGCCCTGGT GGCCCACGGT GCTACCCGTC ATGACGCGTC
3801 ATGGGTGATA CCCCTATCAG CGTTGATTTC ATGCGGTTTG ATGCCCCGGG
3851 TGACACCCCC TGATGCCCCG TCACCCAATA ACGTGGCGCC TGCCATGACG
3901 TCCCACGGTG ACGCCCCCCT GACGGGGGAA GTCCAAGAGC TGCGCGAGCG
3951 ACTGGCCAAC GCTGAGCATC GAGCCGAGCT AGCCGAAGCC ATCGCGGCCG
4001 AGCGACAACA CACGATCGAC GCCCAGCGCA TCGCCTTACG GGCCTTAGAA
4051 CCCGGCTCGA CCCATAACAG CCCGGCAACC GATGAGCCGG CTACCGCTCG
4101 CGAGCAACCT CCCGGTCCAG AACCCAGCGA CTCCAGGCCA CACCGCCGGA
4151 GTTGGTGGCG TCGGCTGACT GGTGGCGCCT GACCGGCCCC GGTCGTCTTC
4201 GAGGGGAACC TCTCGCCTGC GAGAGGACAC AGCAGCCGGC TGTGCTGGTA
4251 GGGCATCCCA GCACGACACC CCTCTGACGC GAGAAGTTCA AGGACTACGC
4301 GAATTGCTGA CTACCGCCGA GCGGCAGCAC ACGATCGAGA TGCTCAACGA
4351 ACCGCACTAC GCGGCCTTAG AAGGCCCCAA GGCACGCTCA CCTACCACGT
4401 GGATCACCAC CGATCGGCGC CGACAGCTAT GGACCCCATC GCAAGATCAA
4451 AACCCCTGAG CAGCCATCGC ACCGAGCGCC CGGCACGCCG GAAGAAGCTC
4501 CGACGCCCCT GCTGTCCGGA CACGGCCTAA CGCGTCCAGA CCAGAACCAG
4551 TGCTCCGATC TAAACCGAAG GCCCTTCATG TGAGAGCATA GTCGTGACGT
4601 CGGCACAGTA GTCGTGCCCG GCGGGGGTAA CGCTACACAA CGCTTAAAAA
4651 GCATCGGAGC AAGCTAACAC AGGGGGACTG ATGAACAAAA CACACAAAAT
4701 GGCGACGCTG GTAATTGCCG CGATCTTGGC CGCCGGAATG ACCGCACCAA
4751 CTGCCTATGC AGATTCTCCT GGAAACACCA GAATTACAGC CAGCGAGCAA
4801 AGCGTCCTTA CCCAGATACT CGGCCACAAA CCTACACAAA CTGAATATAA
4851 CCGATACGTT GAGACTTACG GAAGCGTACC GACCGAAGCA GACATCAACG
4901 CATATATAGA AGCGTCTGAA TCTGAGGGAT CATCAAGTCA AACGGCTGCT
4951 CACGATGACT CGACATCACC CGGCACGAGT ACCGAAATCT ACACGCAGGC
5001 AGCCCCTGCC AGGTTCTCAA TGTTTTTCCT GTCCGGAACT TGGATCACTA
5051 GGAGTGGTGT AGTATCGCTC TCCTTGAAGC CAAGGAAGGG TGGTATTGGC
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FIGURE 11 (Sheet 3 of 7)

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5101 AACGAGGGGG ACGAGCGTAC CTGGAAGACT GTATACGACA AATTCCATAA
5151 CGCTGGGCAA TGGACACGAT ACAAGAACAA CGGCGTAGAC GCCAGCATGA
5201 AAAAGCAGTA CATGTGCCAC TTCAAGTACG GGATGGTGAA GACGCCATGG
5251 GTGTGCCATT TCTCACAATC CCGGGGTGCG ATTGTCGCGT TTCCCACAGG
5301 AATCGGCGCG GGGATCTGGA GGGTGCTGCG ACACGCCCAT ATTTTGAACG
5351 ATGTTCAGTG CGTCAACCTC GACCCCAGTG CTGAACTTGT CCGTCGCGGG
5401 TGCAAGGATT GGACCCATGA GTCCGCGAAA GATTGGCGTT ACCGAGCTCG
5451 CGCTCCGCGA CGCGCATCAG AGCCTGATTG CAACCCGGAT GACTGAGTTG
5501 GACACCATCG CAAATCCGTC CGATCCCGCG GTGCAGCGGA TCATCGATGT
5551 CACCAAGCCG TCGCGATCCA ACATAAAGAC AACGTTGATC GAGGACGTCG
5601 AGCCCCTCAT GCACAGCATC GCGGCCGGGG TGGAGTTCAT CGAGGTCTAC
5651 GGCAGCGACA GCAGTCCTTT TCCATCTGAG TTGCTGGATC TGTGCGGGCG
5701 GCAGAACATA CCGGTCCGCC TCATCGACTC CTCGATCGTC AACCAGTTGT
5751 TCAAGGGGGA GCGGAAGGCC AAGACATTCG GCATCGCCCG CGTCCCTCGC
5801 CCGGCCAGGT TCGGCGATAT CGCGAGCCGG CGTGGGGACG TCGTCGTTCT
5851 CGACGGGGTG AAGATCGTCG GGAACATCGG CGCGATAGTA CGCACGTCGC
5901 TCGCGCTCGG AGCGTCGGGG ATCATCCTGG TCGACAGTGA CATCACCAGC
5951 ATCGCGGACC GGCGTCTCCA AAGGGCCAGC CGAGGTTACG TCTTCTCCCT
6001 TCCCGTCGTT CTCTCCGGTC GCGAGGAGGC CATCGCCTTC ATTCGGGACA
6051 GCGGTATGCA GCTGATGACG CTCAAGGCGG ATGGCGACAT TTCCGTGAAG
6101 GAACTCGGGG ACAATCCGGA TCGGCTGGCC TTGCTGTTCG GCAGCGAAAA
6151 GGGTGGGCCT TCCGACCTGT TCGAGGAGGC GTCTTCCGCC TCGGTTTCCA
6201 TCCCCATGAT GAGCCAGACC GAGTCTCTCA ACGTTTCCGT TTCCCTCGGA
6251 ATCGCGCTGC ACGAGAGGAT CGACAGGAAT CTCGCGGCCA ACCGATAATC
6301 AGGCTGAGAA CGACCTGATC CGCCACTCGC GGAACTCCGG ACGCCGCGTC
6351 CCCTCGGGGG CGCGGCGTCC TGCATGTCCG GGCGCAGGGG CAAGGCAGGC
6401 CTCCTACTTA TAATTGTCCC ATACGCGTCA TACTGGTTAG TCGCTGGAGA
6451 TCCAGACGTT TGGGACTTCT ATCGTTCTTT ATGGTGGATT CCAGTGGCTT
6501 TTCTAGGAAT AGTTTCAATA GTACTGATGG CTAGCAGTAG AGGTTGGGGA
6551 CGACGTCTCG GCGACTCCGG AGAACACCAA GTCAGGGTCT CATGAGTGTG
6601 CGATAGCTTG AGCTGTCTAC CAATCTGGAT ATAGCTATAT CGGTCGTTTG
6651 TGTCTGATTC GCCAGTGAGC CAACGGCGGG GGCGACACGC GGTGGCGAAA
6701 CCCCCTGGCA GAATTCGTAA TCATGGTCAT AGCTGTTTCC TGTGTGAAAT
6751 TGTTATCCGC TCACAATTCC ACACAACATA CGAGCCGGAA GCATAAAGTG

FIGURE 11 (Sheet 4 of 7)

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6801 TAAAGCCTGG GGTGCCTAAT GAGTGAGCTA ACTCACATTA ATTGCGTTGC
6851 GCTCACTGCC CGCTTTCCAG TCGGGAAACC TGTCGTGCCA GCTGCATTAA
6901 TGAATCGGCC AACGCGCGGG GAGAGGCGGT TTGCGTATTG GGCGCTCTTC
6951 CGCTTCCTCG CTCACTGACT CGCTGCGCTC GGTCGTTCGG CTGCGGCGAG
7001 CGGTATCAGC TCACTCAAAG GCGGTAATAC GGTTATCCAC AGAATCAGGG
7051 GATAACGCAG GAAAGAACAT GTGAGCAAAA GGCCAGCAAA AGGCCAGGAA
7101 CCGTAAAAAG GCCGCGTTGC TGGCGTTTTT CCATAGGCTC CGCCCCCCTG
7151 ACGAGCATCA CAAAAATCGA CGCTCAAGTC AGAGGTGGCG AAACCCGACA
7201 GGACTATAAA GATACCAGGC GTTTCCCCCT GGAAGCTCCC TCGTGCGCTC
7251 TCCTGTTCCG ACCCTGCCGC TTACCGGATA CCTGTCCGCC TTTCTCCCTT
7301 CGGGAAGCGT GGCGCTTTCT CAAAGCTCAC GCTGTAGGTA TCTCAGTTCG
7351 GTGTAGGTCG TTCGCTCCAA GCTGGGCTGT GTGCACGAAC CCCCCGTTCA
7401 GCCCGACCGC TGCGCCTTAT CCGGTAACTA TCGTCTTGAG TCCAACCCGG
7451 TAAGACACGA CTTATCGCCA CTGGCAGCAG CCACTGGTAA CAGGATTAGC
7501 AGAGCGAGGT ATGTAGGCGG TGCTACAGAG TTCTTGAAGT GGTGGCCTAA
7551 CTACGGCTAC ACTAGAAGAA CAGTATTTGG TATCTGCGCT CTGCTGAAGC
7601 CAGTTACCTT CGGAAAAAGA GTTGGTAGCT CTTGATCCGG CAAACAAACC
7651 ACCGCTGGTA GCGGTGGTTT TTTTGTTTGC AAGCAGCAGA TTACGCGCAG
7701 AAAAAAAGGA TCTCAAGAAG ATCCTTTGAT CTTTTCTACG GGGTCTGACG
7751 CTCAGTGGAA CGAAAACTCA CGTTAAGGGA TTTTGGTCAT GAGATTATCA
7801 AAAAGGATCT TCACCTAGAT CCTTTTAAAT TAAAAATGAA GTTTTAAATC
7851 AATCTAAAGT ATATATGAGT AAACTTGGTC TGACAGTTAC CAATGCTTAA
7901 TCAGTGAGGC ACCTATCTCA GCGATCTGTC TATTTCGTTC ATCCATAGTT
7951 GCCTGACTCC CCGTCGTGTA GATAACTACG ATACGGGAGG GCTTACCATC
8001 TGGCCCCAGT GCTGCAATGA TACCGCGAGA CCCACGCTCA CCGGCTCCAG
8051 ATTTATCAGC AATAAACCAG CCAGCCGGAA GGGCCGAGCG CAGAAGTGGT
8101 CCTGCAACTT TATCCGCCTC CATCCAGTCT ATTAATTGTT GCCGGGAAGC
8151 TAGAGTAAGT AGTTCGCCAG TTAATAGTTT GCGCAACGTT GTTGCCATTG
8201 CTACAGGCAT CGTGGTGTCA CGCTCGTCGT TTGGTATGGC TTCATTCAGC
8251 TCCGGTTCCC AACGATCAAG GCGAGTTACA TGATCCCCCA TGTTGTGCAA
8301 AAAAGCGGTT AGCTCCTTCG GTCCTCCGAT CGTTGTCAGA AGTAAGTTGG
8351 CCGCAGTGTT ATCACTCATG GTTATGGCAG CACTGCATAA TTCTCTTACT
8401 GTCATGCCAT CCGTAAGATG CTTTTCTGTG ACTGGTGAGT ACTCAACCAA
8451 GTCATTCTGA GAATAGTGTA TGCGGCGACC GAGTTGCTCT TGCCCGGCGT

FIGURE 11 (Sheet 5 of 7)

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8501 CAATACGGGA TAATACCGCG CCACATAGCA GAACTTTAAA AGTGCTCATC
8551 ATTGGAAAAC GTTCTTCGGG GCGAAAACTC TCAAGGATCT TACCGCTGTT
8601 GAGATCCAGT TCGATGTAAC CCACTCGTGC ACCCAACTGA TCTTCAGCAT
8651 CTTTTACTTT CACCAGCGTT TCTGGGTGAG CAAAAACAGG AAGGCAAAAT
8701 GCCGCAAAAA AGGGAATAAG GGCGACACGG AAATGTTGAA TACTCATACT
8751 CTTCCTTTTT CAATATTATT GAAGCATTTA TCAGGGTTAT TGTCTCATGA
8801 GCGGATACAT ATTTGAATGT ATTTAGAAAA ATAAACAAAT AGGGGTTCCG
8851 CGCACATTTC CCCGAAAAGT GCCACCTGAC GTCTAAGAAA CCATTATTAT
8901 CATGACATTA ACCTATAAAA ATAGGCGTAT CACGAGGCCC TTTCGTCTCG
8951 CGCGTTTCGG TGATGACGGT GAAAACCTCT GACACATGCA GCTCCCGGAG
9001 ACGGTCACAG CTTGTCTGTA AGCGGATGCC GGGAGCAGAC AAGCCCGTCA
9051 GGGCGCGTCA GCGGGTGTTG GCGGGTGTCG GGGCTGGCTT AACTATGCGG
9101 CATCAGAGCA GATTGTACTG AGAGTGCACC ATATGCGGTG TGAAATACCG
9151 CACAGATGCG TAAGGAGAAA ATACCGCATC AGGCGCCATT CGCCATTCAG
9201 GCTGCGCAAC TGTTGGGAAG GGCGATCGGT GCGGGCCTCT TCGCTATTAC
9251 GCCAGCTGGC GAAAGGGGGA TGTGCTGCAA GGCGATTAAG TTGGGTAACG
9301 CCAGGGTTTT CCCAGTCACG ACGTTGTAAA ACGACGGCCA GTGCCACTAG
9351 AGTGTGCCAT TTCTCACAAT CCCGGGGTGC GATTGTCGCG TTTCCCACAG
9401 GAATCGGCGC GGGGATCTGG AGGGTGCTGC GACACGCCCA TATTTTGAAC
9451 GATGTTCAGT GCGTCAACCT CGACCCCAGT GCTGAACTTG TCCGTCGCGG
9501 GTGCAAGGAT TGGACCCATG AGTCCGCGAA AGATTGGCGT TACCGAGCTC
9551 GCGCTCCGCG ACGCGCATCA GAGCCTGATT GCAACCCGGA TGAAGGTCAC
9601 CACCGTCAAG GAGCTGGACG AGAAGCTCAA GGTCATCAAG GAGGCCCAGA
9651 AGAAGTTCTC GTGCTACTCG CAGGAGATGG TGGACGAGAT CTTCCGCAAC
9701 GCCGCGATGG CCGCGATCGA CGCCCGCATC GAGCTCGCCA AGGCCGCGGT
9751 CCTGGAGACC GGCATGGGCC TCGTCGAGGA CAAGGTGATC AAGAACCACT
9801 TCGCCGGCGA GTACATCTAC AACAAGTACA AGGACGAGAA GACCTGCGGC
9851 ATCATCGAGC GCAACGAGCC GTACGGCATC ACCAAGATCG CCGAGCCCAT
9901 CGGCGTCGTC GCCGCGATCA TCCCCGTCAC CAACCCGACC TCCACCACGA
9951 TCTTCAAGTC GCTGATCTCG CTCAAGACCC GCAACGGCAT CTTCTTCTCG
10001 CCGCACCCGC GCGCCAAGAA GTCGACCATC CTGGCCGCGA AGACCATCCT
10051 GGACGCCGCG GTCAAGTCGG GCGCCCCCGA GAACATCATC GGCTGGATCG
10101 ACGAGCCCTC GATCGAGCTG ACCCAGTACC TGATGCAGAA GGCCGACATC
10151 ACCCTCGCCA CCGGCGGGCC CTCGCTCGTC AAGTCGGCCT ACTCGTCCGG
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FIGURE 11 (Sheet 6 of 7)

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10201 CAAGCCCGCC ATCGGCGTGG GGCCGGGCAA CACCCCCGTC ATCATCGACG
10251 AGTCCGCCCA CATCAAGATG GCCGTCTCCT CCATCATCCT CTCCAAGACC
10301 TACGACAACG GCGTCATCTG CGCCTCGGAG CAGTCCGTGA TCGTCCTCAA
10351 GTCGATCTAC AACAAGGTCA AGGACGAGTT CCAGGAGCGC GGCGCCTACA
10401 TCATCAAGAA GAACGAGCTG GACAAGGTGC GCGAGGTCAT CTTCAAGGAC
10451 GGCTCGGTGA ACCCCAAGAT CGTCGGCCAG TCGGCCTACA CCATCGCCGC
10501 GATGGCCGGC ATCAAGGTCC CGAAGACCAC GCGCATCCTC ATCGGCGAGG
10551 TCACCTCCCT GGGCGAGGAG GAGCCCTTCG CCCACGAGAA GCTCTCGCCC
10601 GTCCTGGCCA TGTACGAGGC CGACAACTTC GACGACGCCC TCAAGAAGGC
10651 CGTCACCCTG ATCAACCTCG GCGGGCTGGG CCACACCTCC GGCATCTACG
10701 CCGACGAGAT CAAGGCCCGC GACAAGATCG ACCGCTTCTC CTCGGCCATG
10751 AAGACCGTCC GCACCTTCGT CAACATCCCC ACCTCGCAGG GCGCCTCCGG
10801 CGACCTGTAC AACTTCCGCA TCCCGCCCTC CTTCACCCTC GGCTGCGGCT
10851 TCTGGGGGGG CAACTCCGTC TCGGAGAACG TGGGCCCGAA GCACCTGCTG
10901 AACATCAAGA CCGTGGCCGA GCGCCGCGAG AACATGCTGT GGTTCCGCGT
10951 CCCCCACAAG GTCTACTTCA AGTTCGGCTG CCTCCAGTTC GCCCTCAAGG
11001 ACCTCAAGGA CCTCAAGAAG AAGCGCGCCT TCATCGTCAC CGACTCGGAC
11051 CCCTACAACC TGAACTACGT CGACTCCATC ATCAAGATCC TCGAGCACCT
11101 CGACATCGAC TTCAAGGTCT TCAACAAGGT GGGCCGCGAG GCCGACCTCA
11151 AGACCATCAA GAAGGCCACC GAGGAGATGT CGTCCTTCAT GCCCGACACC
11201 ATCATCGCCC TGGGCGGGAC CCCGGAGATG TCCTCCGCCA AGCTGATGTG
11251 GGTCCTCTAC GAGCACCCCG AGGTCAAGTT CGAGGACCTG GCCATCAAGT
11301 TCATGGACAT CCGCAAGCGC ATCTACACCT TCCCCAAGCT GGGCAAGAAG
11351 GCCATGCTCG TGGCCATCAC CACGTCCGCC GGCTCCGGCT CCGAGGTCAC
11401 CCCCTTCGCC CTCGTGACCG ACAACAACAC CGGCAACAAG TACATGCTCG
11451 CCGACTACGA GATGACCCCC AACATGGCCA TCGTGGACGC CGAGCTCATG
11501 ATGAAGATGC CGAAGGGCCT CACCGCCTAC TCGGGCATCG ACGCCCTGGT
11551 CAACTCGATC GAGGCCTACA CCTCCGTCTA CGCCTCCGAG TACACCAACG
11601 GCCTCGCCCT CGAGGCCATC CGCCTGATCT TCAAGTACCT CCCGGAGGCC
11651 TACAAGAACG GCCGCACCAA CGAGAAGGCC CGCGAGAAGA TGGCCCACGC
11701 GTCCACCATG GCCGGCATGG CGTCCGCCAA CGCCTTCCTC GGCCTCTGCC
11751 ACTCCATGGC CATCAAGCTG TCCTCGGAGC ACAACATCCC CTCCGGCATC
11801 GCCAACGCCC TCCTCATCGA GGAGGTCATC AAGTTCAACG CCGTGGACAA
11851 CCCGGTGAAG CAGGCCCCCT GCCCGCAGTA CAAGTACCCC AACACCATCT

11901 TCCGCTACGC CCGCATCGCC GACTACATCA AGCTGGGCGG GAACACCGAC
11951 GAGGAGAAGG TCGACCTCCT CATCAACAAG ATCCACGAGC TCAAGAAGGC
12001 CCTCAACATC CCGACCTCCA TCAAGGACGC CGGCGTGCTG GAGGAGAACT
12051 TCTACTCCTC CCTGGACCGC ATCTCGGAGC TCGCCCTGGA CGACCAGTGC
12101 ACCGGCGCCA ACCCGCGCTT CCCGCTCACC TCCGAGATCA AGGAGATGTA
12151 CATCAACTGC TTCAAGAAGC AGCCCTGATG ATCAGGCTGA GAACGACCTG
12201 ATCCGCCACT CGCGGAACTC CGGACGCCGC GTCCCCTCGG GGGCGCGGCG
12251 TCCTGCATGT CCGGGCGCAG GGGCAAGGCA GGCCTCCTAC A
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FIGURE 11 (Sheet 7 of 7)

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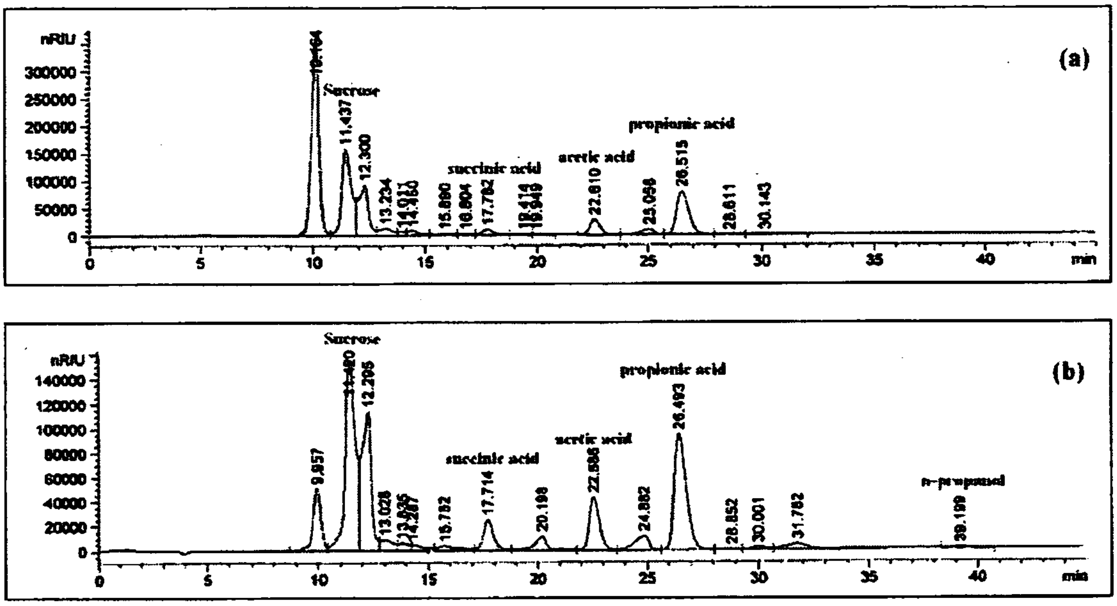

FIGURE 12

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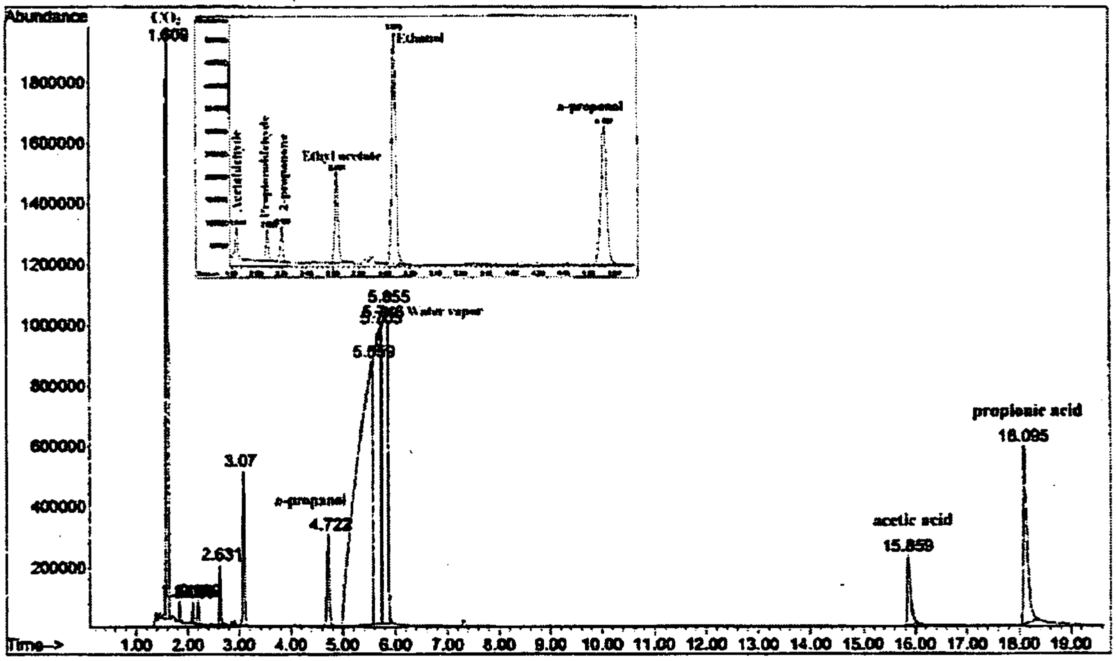

FIGURE 13

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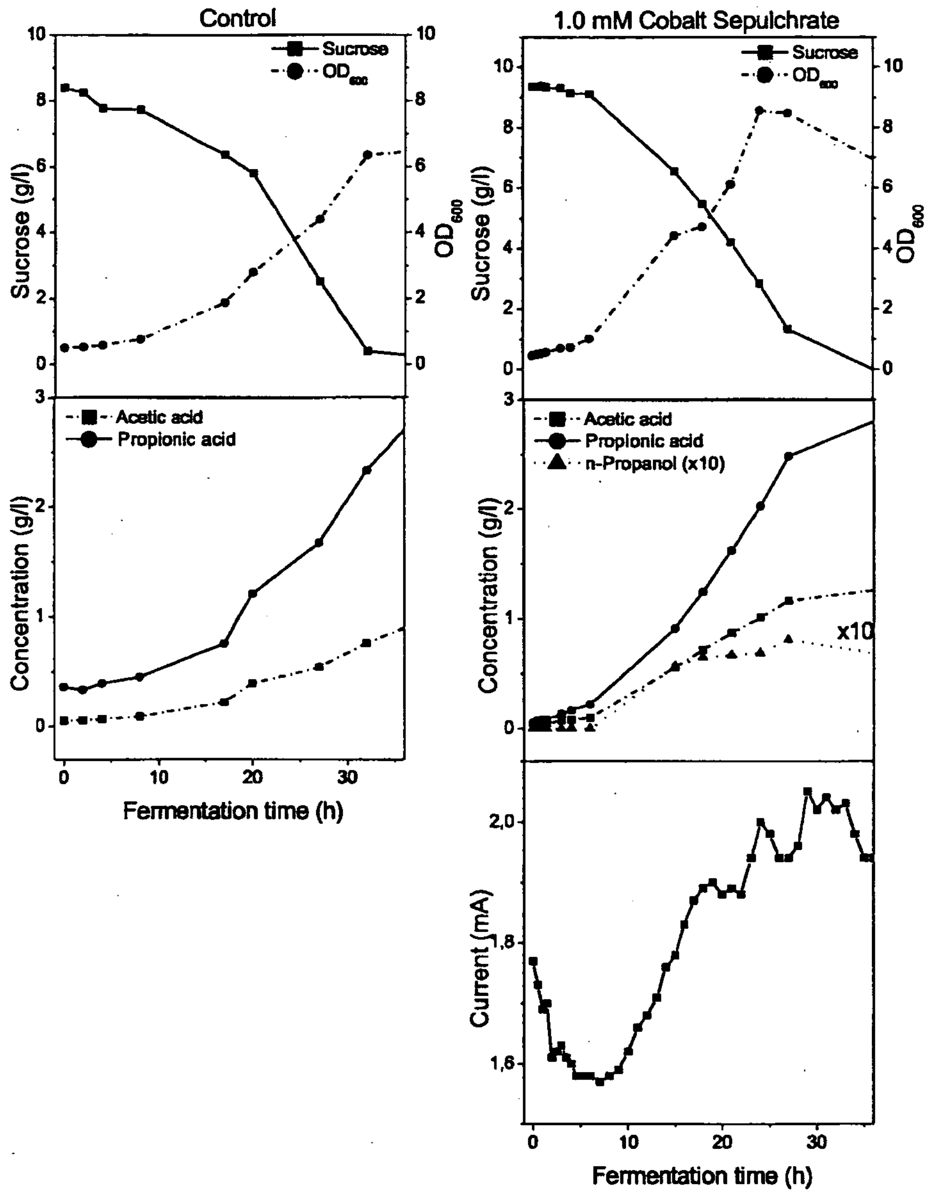

FIGURE 14

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FIELD OF THE INVENTION

The present invention relates to a process of bioconverting a biobased substrate (such as sugarcane juice, hydrolyzed starch, hydrolyzed cellulose or glycerol) into n-propanol using genetically modified microorganisms combined with a process for supplying reducing equivalents in the form of NAD(P)H during fermentation. The biobased n-propanol thus obtained could be dehydrated to propylene and polymerized to polypropylene to yield a bioplastic.

BACKGROUND OF THE INVENTION

n-Propanol (1-propanol, primary propyl alcohol, propan-1-ol) is a non-hazardous solvent that is freely miscible with water and other common solvents, with numerous applications in industry, such as printing inks, coatings, cleaners, adhesives, herbicides, insecticides, pharmaceuticals, de-icing fluids and as a chemical intermediate for the production of esters, propylamines, halides and thermoplastic resins. The use of n-propanol in fuel blends has also been suggested (U.S. Pat. No. 6,129,773), as this alcohol has the same capacity of ethanol to be used to increase as an antiknock additive and increase the octane number of gasoline according to Barannik V. P. et al. 2005, Chemistry and Technology of Fuels and Oils 41(6): 452-455.

n-Propanol is one of the main constituents of "fusel oils" or "potato oils", which are the higher-order alcohols by-products of ethanol fermentation by the yeast *Saccharomyces cerevisiae* (Hazelwood et al. 2008. The Ehrlich Pathway for Fusel Alcohol Production: a Century of Research on *Saccharomyces cerevisiae* Metabolism. Applied and Environmental Microbiology 74(8): 2259-2266). In the past, n-Propanol was obtained by fractional distillation of fusel oil, but nowadays it is manufactured from fossil feedstocks in a two-stage process known as Oxo Process, comprising ethylene hydroformylation at 80-120°C and 2.0 MPa in the presence of cobalt or rhodium carbonyl followed by hydrogenation of the resulting propionaldehyde on a copper-chromium, nickel-chromium or porous cobalt catalyst (U.S. Pat. No. 4,263,449 and U.S. Pat. No 5,866,725).

Worldwide interest in organic compounds produced from renewable feedstocks has increased considerably in recent years, especially for compounds that can be used as fuels or as bulk chemicals for the petrochemical industry. The latter are particularly interesting, since these compounds could be fixed in highly durable materials that can be recycled, thus effectively mitigating atmospheric CO_2 (Rincones et al. 2009. The golden bridge for nature: the new biology applied to bioplastics. Polymer Reviews 49: 85-106). Thus, the use of the chemical products obtained from renewable feedstocks is becoming increasingly accepted and widespread as a viable alternative aiming at decreasing our society's dependence on fossil carbon sources. Products obtained from green sources can be certified as to their renewable carbon content according to the methodology described by the technical norm ASTM D 6866-06: "Standard Test Methods for Determining the Biobased Content of Natural Range Materials Using Radiocarbon and Isotope Ratio Mass Spectrometry Analysis".

The production of short-chain organic solvents (mainly reduced alcohols) through microorganism fermentation has been extensively studied. The most dramatic example is the production of ethanol as a commodity chemical, which is a major industrial process reaching nearly 90 million m^3/year and occurring by the fermentation of renewable carbon sources (mainly cornstarch and sugarcane juice) by the yeast *Saccharomyces cerevisiae.* This process is extremely efficient and has been refined to the point where ethanol distilled from the fermentation broth is obtained at 90-95% of the theoretical yield. The ethanol thus produced is used as an industrial solvent, as the main additive for gasoline in fuel blends and, in Brazil, is used as the sole fuel for small vehicles. Another use of a biobased ethanol is the manufacture of bio-ethylene to be used as a monomer in the polyethylene manufacture, through a dehydration reaction as described by Morschbacker A. L. 2009, Bio-Ethanol Based Ethylene, Journal of Macromolecular Science, Part C: Polymer Reviews, 49:79–84.

Other well-known examples of solvent production by fermentation are the Acetone-Butanol-Ethanol (ABE) and the Isopropanol-Butanol-Ethanol (IBE) fermentations performed by some bacterial species of the genus *Clostridium*, yielding more than 35% by weight of the solvent mixture (U.S. Pat. No. 5,192,673). In addition, fermentation of 2,3-butanediol from carbohydrates by enteric bacteria of the genera *Klebsiella* and *Enterobacter* yields up to 47% by weight (Ji et al., 2009, Bioresource Technology 100:3410-3414). A recent success is the fermentative production of 1,3 propanediol from glucose in a single microorganism with high yield (35% w/w) and titer (129 g/L) (U.S. Pat. No. 7,169,588 B2; U.S. Pat. No. 7,067,300 B2; U.S. Pat. No. 5,686,276). The establishment of an industrial process for the production of this low cost