

**LEGIONELLA SPECIFIC ANTIBIOTIC,  
A MICROORGANISM PRODUCING THE  
ANTIBIOTIC AND A PROCESS FOR  
PRODUCING THE SAME**

5

**FIELD OF THE INVENTION**

The present invention is directed to a novel *Legionella* specific antibiotic AL072, a novel *Streptomyces* sp. AL91  
10 producing the same, and a process for producing the said antibiotic.

**BACKGROUND OF THE INVENTION**

15 *Legionella pneumophila*, which is the causal agent of *Legionella* infections, has been known to cause Legionnaires' disease or Pontiac fever. Since the bacteria was first isolated in Philadelphia, USA, it has been reported that many isolations of a species of *Legionella* were made  
20 from various patients and environments in all parts of the world, including the USA, and 10 or more species were identified. *Legionella pneumophila* is one of the pathogens capable of causing pneumonia and it is presumed that 5% of the occurrences of pneumonia are due to *Legionella*  
25 *pneumophila*. *Legionella pneumophila* grows in air-conditioning cooling towers, water service pipes, drain pipes, etc., and infections are believed to occur in respiratory organs by inhalation of contaminated aerosols. In July, 1984, criticism was caused by the surprising fact that ill-defined  
30 symptoms of pneumonia which occurred in patients as well as medical teams at intensive care units of Koryo Hospital in Seoul appeared to be caused by *Legionella* species. According to a result of investigation completed in 1985 by

the National Health Institute, at least 90% of air-conditioning cooling towers within Seoul were contaminated with *Legionella* species and 93% of the isolated *Legionella* were identified as *Legionella pneumophila*. An additional  
5 investigation completed by the National Health Institute in major cities throughout the country, for example Seoul, Pusan, Daejeon, etc., between June and September, 1988 revealed that 83% of the isolated *Legionella* were classified to *Legionella pneumophila* serogroup 1.

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Macrolide antibiotics, such as erythromycin, and quinolone antibiotics, such as rifampin, are known to be active against *Legionella* species and have been used for the treatment of the *Legionella* infections. However, these antibiotics have a  
15 wide spectrum of activity against a variety of microbes, in addition to the *Legionella* species. In this regard, an abuse of such antibiotics for extended periods may not only generate resistance to various microbes but also cause harmful problems such as the collapse of the balance of  
20 microbes occurring in a human body.

Additionally, there have been serious problems in that chemical agents for disinfecting air-conditioning cooling towers, which are contamination sources of *Legionella*  
25 species, may result in the contamination of the environment and the corrosion of the air-conditioning device.

Therefore, the development of novel *Legionella* specific antibiotics which are specifically active against only  
30 *Legionella* species, is needed and thereby may minimize the undesired problems. We have intensively investigated soil microbes over several years for the purpose of developing such antibiotics. Eventually, we succeeded in isolating a species of *Streptomyces* producing *Legionella* specific  
35 antibiotics and purifying a novel antibiotic specifically active

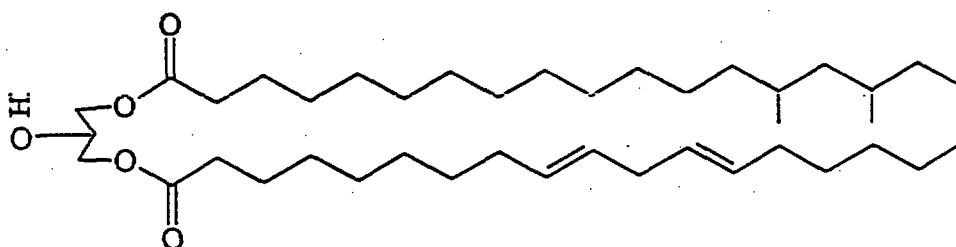
against only *Legionella* species, which is designated Antibiotic AL072.

## SUMMARY OF THE INVENTION

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Cultivation of the novel microorganism *Streptomyces* sp. AL91 yields a novel antibiotic substance AL072 which is active exclusively against *Legionella* species, whose structure is represented as follows:

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## 20 DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the ultraviolet absorption spectrum of antibiotic substance AL072.

FIG. 2 shows the infrared absorption spectrum of antibiotic  
25 substance AL072.

FIG. 3 shows the mass spectrum of antibiotic substance AL072 measured by FAB/MS.

FIG. 4 shows the 400 MHz proton nuclear magnetic resonance spectrum of antibiotic substance AL072.

30 FIG. 5 shows the 100 MHz carbon nuclear magnetic resonance spectrum of antibiotic substance AL072.

## DETAILED DESCRIPTION OF THE INVENTION

## The Microorganism

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The microorganism used for the production of *Legionella* specific antibiotic substance AL072 is *Streptomyces* sp. AL91. The microorganism was deposited at the permanent collection of the Korean Culture Center of Microorganisms, 10 Seoul, Korea, on June 2, 1994 under the Budapest Treaty on the international recognition of the deposit of microorganisms for the purposes of patent procedure, and a subculture of the organism can be obtained from the repository under the accession number KCCM 10055. In addition to the specific 15 microorganism described and characterized herein, it should be understood that mutants of the microorganism (e.g., mutants produced through the use of X-ray, ultraviolet radiation or nitrogen mustards) can also be cultivated to produce the antibiotic substance AL072.

20

Isolation of *Streptomyces* sp. AL91 was accomplished by shaking 1.0g of dried soil sample in 10ml of sterile distilled water, plating 0.1ml of dilutions of the soil suspension on a Humic acid-Vitamin agar supplemented with Cycloheximide 25 (50 $\mu$ g/ml) and Nalidixic acid (200 $\mu$ g/ml), and cultivating the plate at the temperature of 28 $^{\circ}$ C for 14-21 days. The medium was sterilized at 121 $^{\circ}$ C for 15 minutes before the antifungal agent Cycloheximide and the antibacterial agent Nalidixic acid, separately sterilized by filtration, were added. The 30 composition of Humic acid-Vitamin agar is described in Table I.

Table I

|    |                                       |         |
|----|---------------------------------------|---------|
|    | Humic acid                            | 1.0g    |
|    | (dissolved in 10ml of 0.2 N NaOH)     |         |
| 5  | Na <sub>2</sub> HPO <sub>4</sub>      | 0.5g    |
|    | KCl                                   | 1.71g   |
|    | MgSO <sub>4</sub> · 7H <sub>2</sub> O | 0.05g   |
|    | FeSO <sub>4</sub> · 7H <sub>2</sub> O | 0.01g   |
|    | Thiamin-HCl                           | 0.5g    |
| 10 | Vitamin B <sub>2</sub>                | 0.5g    |
|    | Niacin                                | 0.5g    |
|    | Pyridoxine-HCl                        | 0.5g    |
|    | Inositol                              | 0.5g    |
|    | Pantothenic Acid Ca-salt              | 0.5g    |
| 15 | p-Aminobenzoic Acid                   | 0.5g    |
|    | Biotin                                | 0.25mg  |
|    | Cycloheximide                         | 50mg    |
|    | Nalidixic acid                        | 200g/mL |
|    | Agar                                  | 20g     |
| 20 | Distilled water(pH 7.0)               | 1L      |

#### Characteristics of *Streptomyces* sp. AL91 KCCM 10055

- 25 Morphology: Spores are formed by spiral, branched chains.  
The surface of spores is smooth.

Biochemical characteristics: The ability to liquefy gelatin is negative and the ability to degrade starch is positive.

30

35

## Cultural characteristics:

|    | Media                                  | Growth | Color of<br>aerial mycelium | Reverse<br>color | Soluble<br>pigments |
|----|----------------------------------------|--------|-----------------------------|------------------|---------------------|
| 5  | Trypton-yeast<br>extract agar          | good   | brown                       | brown            | brown               |
| 10 | Yeast extract-<br>malt extract<br>agar | good   | white                       | brown            | -                   |
| 15 | Oat meal<br>extract agar               | good   | pale orange<br>or white     | -                | -                   |
|    | Inorganic salt-<br>starch agar         | good   | white                       | -                | -                   |
| 20 | Glycerol-<br>asparagine agar           | good   | dense yellow                | dense yellow     | -                   |
| 25 | Peptone-yeast<br>extract-iron<br>agar  | poor   | dense brown                 | brown            | dense brown         |
|    | Tyrosine agar                          | good   | white-brown                 | dense brown      | -                   |
| 30 | Bennett' medium                        | good   | white                       | yellow-brown     | -                   |

## Carbon utilization:

Positive: D-Glucose, sucrose, D-xylose, D-mannitol,  
D-fructose, rhamnose, raffinose, cellulose.

35 Negative: L-Arabinose, I-inositol.

## Susceptibility to antibiotics:

|    | antibiotics     | Concentrations<br>( $\mu\text{g}/\text{mL}$ ) | Diameter of ring produced<br>by inhibition of growth<br>(mm) |
|----|-----------------|-----------------------------------------------|--------------------------------------------------------------|
| 5  |                 |                                               |                                                              |
|    | Carbenicillin   | 100                                           | -                                                            |
|    | Chloramphenicol | 30                                            | 27.7                                                         |
| 10 | Neomycin        | 30                                            | 12.0                                                         |
|    | Nalidixic acid  | 30                                            | -                                                            |
|    | Vancomycin      | 30                                            | 22.0                                                         |
|    | Clindamycin     | 2                                             | -                                                            |
|    | Ampicillin      | 10                                            | 12.0                                                         |
| 15 | Kanamycin       | 30                                            | 17.0                                                         |
|    | Tetracycline    | 30                                            | 17.0                                                         |
|    | Cephalothin     | 30                                            | 24.0                                                         |
|    | Erythromycin    | 15                                            | 40.0                                                         |
|    | Rifampin        | 5                                             | -                                                            |
| 20 | Gentamycin      | 10                                            | 10.0                                                         |
|    | Streptomycin    | 10                                            | 17.0                                                         |

## 25      Production of the Antibiotic substance AL072

30 *Streptomyces* sp. AL91 KCCM 10055 was grown on a  
 nutrient agar containing the components listed in Table II for  
 3 days. The cultures were inoculated into 200 mL of a liquid  
 medium containing the components listed in Table III and  
 cultivated at the temperature of 28°C under aerobic conditions  
 for 3 days. Subsequently, the culture solution was inoculated  
 into 6 L of a liquid medium containing the components listed  
 in Table IV and cultivated at the temperature of 28°C under  
 35 aerobic conditions for 5 days. The antibiotic AL072 was

isolated and purified from the final culture solution by the procedures described below.

Table II

|    |                                 |       |
|----|---------------------------------|-------|
| 5  | Sucrose                         | 20.0g |
|    | Glucose                         | 10.0g |
|    | Corn steep liquor               | 5mg   |
|    | Yeast extracts                  | 4.9g  |
|    | Soybean flour                   | 20.0g |
| 10 | CaCO <sub>3</sub>               | 4.0g  |
|    | NaCl                            | 2.0g  |
|    | K <sub>2</sub> HPO <sub>4</sub> | 0.05g |
|    | Agar                            | 15g   |
|    | Distilled water (pH 7.3)        | 1L    |

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Table III

|    |                          |     |
|----|--------------------------|-----|
|    | Glucose                  | 1g  |
|    | Soluble starch           | 24g |
|    | Peptone                  | 3g  |
| 20 | Malt extract             | 5g  |
|    | CaCO <sub>3</sub>        | 4g  |
|    | Distilled water (pH 7.0) | 1L  |

Table IV

|    |                                 |       |
|----|---------------------------------|-------|
| 25 | Sucrose                         | 20.0g |
|    | Glucose                         | 10.0g |
|    | Corn steep liquor               | 5ml   |
|    | Yeast extract                   | 4.9g  |
|    | Soybean flour                   | 20.0g |
| 30 | CaCO <sub>3</sub>               | 4.0g  |
|    | NaCl                            | 2.0g  |
|    | K <sub>2</sub> HPO <sub>4</sub> | 0.05g |
|    | Distilled water (pH 7.3)        | 1L    |

35 After cultivation was completed, 6L of the culture solution

was mixed with an equivalent amount of isopropyl alcohol by stirring. After standing over night, the mixture was centrifuged and the resulting supernatant was taken. The supernatant was filtered through the passage of diatomaceous  
5 earth and the filtrate was then concentrated under reduced pressure to remove the isopropyl alcohol. The resulting concentrate was three times extracted with ethylacetate, which was then removed under reduced pressure. The residue was dissolved in 50% isopropyl alcohol and the  
10 resulting solution was then concentrated under reduced pressure to remove the isopropyl alcohol. The residual aqueous solution was passed on a column filled with octadecyl silica gel and the passed solution was discarded. *Legionella* specific antibiotics adhered to the ODS resin were  
15 eluted with 70% ethyl alcohol and the elutes were then concentrated under reduced pressure to dryness. After the dried concentrates were dissolved in 80% isopropyl alcohol, preparative high pressure liquid chromatography (206nm) on silica gel, eluting with acetonitrile-distilled water, 68 : 32 at  
20 the rate of 30mL/min, gave crude *Legionella* specific antibiotic substance AL072. Subsequently, the crude antibiotics were concentrated under reduced pressure todryness, the dried concentrates were dissolved in 50% isopropyl and the resulting solution was again concentrated  
25 under reduced pressure. The isopropyl alcohol was removed and the residue was three times extracted with chloroform. The chloroform was removed and the residue was dissolved in 80% isopropyl alcohol. High pressure liquid chromatography, run in the same conditions as used in the  
30 first chromatography, gave pure antibiotic AL072.

#### Physico-chemical properties of Antibiotic substance AL072

35 1. Thin-layer chromatography was conducted on Merck &

Company No. 5642 HPTLC silica gel plate with the development of chloroform-methyl alcohol, 19:1, Antibiotic AL072 samples were spotted on the silica gel plate and developed in a sealed container. After development, an aqueous 10% sulfuric acid solution containing 5% ammonium molybdate and ceric ammonium sulfate was sprayed on the silica gel plate which was then heated to 100°C for 10 minutes to develop a colour. As a result of this, the Rf value of antibiotic AL072 was 0.58.

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2. Antibiotic AL072 is soluble in alcohols such as methyl alcohol, ethyl alcohol, isopropyl alcohol, etc., and organic solvents such as ethyl acetate, chloroform, etc., whereas it is not or poorly soluble in water.

15

3. Antibiotic AL072 is very stable in aqueous solutions with pH values between pH 2 and pH 12. The activity of antibiotic AL072 is unchanged by heat of 95°C for 1 hour.

20 4. As a result of ultraviolet spectrometry, antibiotic AL072 in methyl alcohol is shown to have a maximum absorption in 242nm(Fig. 1).

25 5. The infrared absorption spectrum of antibiotic AL072 in potassium bromide using Bruker FT-IR spectrometer is shown in Fig. 2.

6. The proton nuclear magnetic resonance spectrum of antibiotic AL072 in CDCl<sub>3</sub> using Bruker ARX400 spectrometer is shown in Fig. 4. <sup>1</sup>H-NMR δ (400MHz): 0.86(3H, m); 0.87(3H, m); 0.88(3H, m); 0.91(3H, m); 1.29(4H, m); 1.61(4H, m), 2.03(2H, m); 2.31(4H, m); 2.75(1H, m); 3.62(1H, dd, 12Hz, 6Hz); 3.72(1H, dd, 4Hz, 12Hz); 3.96(1H, m); 4.14(2H, m); 5.35(4H, m) ppm.

35

7. The carbon nuclear magnetic resonance spectrum of antibiotic AL072 in CDCl<sub>2</sub> using Bruker ARX400 spectrometer is shown in Fig. 5. C-NMR  $\delta$  (100MHz);
- 12.01(q); 14.67(q); 19.85(q); 23.23(q); 23.28(q); 25.34(t);
- 5 25.36(t); 26.29(t); 27.78(t); 27.84(t); 27.87(t); 28.10(t);
- 28.63(d); 29.72(t); 29.75(t); 29.82(t); 29.93(t); 30.02(t);
- 30.17(t); 30.26(t); 30.29(t); 30.33(t); 30.36(t); 30.38(t);
- 30.62(t); 30.69(t); 32.20(t); 34.79(t); 34.81(t); 35.08(d);
- 37.33(t); 39.75(t); 63.90(t); 65.95(t); 70.96(d); 128.50(d);
- 10 128.70(d); 130.60(d); 130.70(d); 174.9(s); 181.00(s)ppm.

#### Biological Activity of Antibiotic substance AL072

The effects of antibiotic substance AL072 obtained according to the above procedures on growth of various microbes were shown in Table V below. It is evident that while the antibiotic substance AL072 is powerfully active against *Legionella pneumophila*, it is not or only slightly active against the other microbes tested.

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Table V

| Microorganism                            | Diameter of ring produced<br>by inhibition of growth<br>(mm) |
|------------------------------------------|--------------------------------------------------------------|
| 5                                        |                                                              |
| <i>Legionella pneumophila</i> ATCC 33152 | 108                                                          |
| <i>Staphylococcus aureus</i>             | 11                                                           |
| <i>Streptococcus pyogenes</i>            | -                                                            |
| 10                                       |                                                              |
| <i>Streptococcus</i>                     | 20                                                           |
| <i>Streptococcus agalactiae</i>          | -                                                            |
| <i>Streptococcus equi</i>                | 21                                                           |
| <i>Streptococcus durans</i>              | 24                                                           |
| <i>Listeria monocytogenes</i>            | 12                                                           |
| 15                                       |                                                              |
| <i>Corynebacterium diphtheriae</i>       | 9                                                            |
| <i>Bacillus subtilis</i>                 | 8                                                            |
| <i>Bacillus megaterium</i>               | 6                                                            |
| <i>Escherichia coli</i>                  | 6                                                            |
| <i>Citrobacter freundii</i>              | -                                                            |
| 20                                       |                                                              |
| <i>Salmonella typhimurium</i>            | 14                                                           |
| <i>Shigella flexneri</i>                 | -                                                            |
| <i>Klebsiella pneumoniae</i>             | -                                                            |
| <i>Klebsiella oxytoca</i>                | -                                                            |
| <i>Klebsiella aerogenes</i>              | -                                                            |
| 25                                       |                                                              |
| <i>Enterobacter cloacae</i>              | -                                                            |
| <i>Enterobacter aerogenes</i>            | 9                                                            |
| <i>Serratia marcescens</i>               | -                                                            |
| <i>Proteus mirabilis</i>                 | -                                                            |
| <i>Proteus vulgaris</i>                  | 12                                                           |
| 30                                       |                                                              |
| <i>Proteus rettgeri</i>                  | -                                                            |
| <i>Proteus morgani</i>                   | -                                                            |
| <i>Pseudomonas aeruginosa</i>            | -                                                            |
| <i>Pseudomonas cepacia</i>               | -                                                            |

The susceptibility of *Legionella* sp. to antibiotic AL072 is tested by the well-known paper disc method. The preculture of *Legionella* sp. is prepared in accordance with a  
 5 conventional manner by using a BCYE medium which consists of the following ingredients:

|    |                             |                       |
|----|-----------------------------|-----------------------|
|    | a. Plate                    |                       |
|    | Yeast Extract               | 11.5g                 |
| 10 | Activated Charcoal          | 1.5g                  |
|    | ACES                        | 6.0g                  |
|    | $\alpha$ -Ketoglutaric Acid | 1.0g                  |
|    | Bacto Agar                  | 17.0g                 |
|    | Distilled Water             | 1.0L                  |
| 15 | pH                          | 7.1-7.2(with 10M KOH) |
|    | b. Enrichment               |                       |
|    | L-Cystein-HCl               | 0.2g                  |
| 20 | Ferric Pyrophosphate        | 0.125g/5ml of D.W.    |

The BCYE medium is sterilized at 1 atmosphere, 121°C for 15 minutes before it is cooled to 50-55°C. The preculture of *Legionella* sp. is diluted with 0.9% saline (NaCl 9.0g + D.W. 1L) in a final concentration of  $5 \times 10^6 - 10^7$  cfu/ml. The  
 25 dilution is dispensed and poured by 10ml into each petri-dish to form test plates. Paper discs with a diameter of 6mm are infiltrated with 20  $\mu$ l of antibiotic AL072 and then well dried. The dried disc is placed on the prepared plate, which is then cultivated in 37°C incubator for 24 hours. The size of ring  
 30 occurring by inhibition of growth is measured with the use of a vernier caliper.

The susceptibility test of *Streptococcus* sp. is conducted in accordance with similar procedures as above described,  
 35 provided that the following medium are used:

## a. Mueller Hinton Medium(Difco)

|   |                      |        |
|---|----------------------|--------|
|   | Beef infusion        | 300.0g |
| 5 | Bacto Casamino Acids | 17.5g  |
|   | Starch               | 1.5g   |
|   | Bacto Agar           | 17.0g  |

## b. Tryptic Soy Broth(Difco)

|    |                                   |       |
|----|-----------------------------------|-------|
| 10 | Bacto Tryptone                    | 17.0g |
|    | pancreatic digest of soybean meal |       |
|    | Bacto Soytone                     | 3.0g  |
|    | papic digest of soybean meal      |       |
|    | Bacto Dextrose                    | 2.5g  |
| 15 | Sodium Chloride                   | 5.0g  |
|    | Dipotassium Phosphate             | 2.5g  |
|    | 10% horse serum                   |       |

The susceptibility of the other aerobic or anaerobic microbes  
20 is tested by similar procedures to *Streptococcus* sp., except  
that the horse serum is unnecessary.

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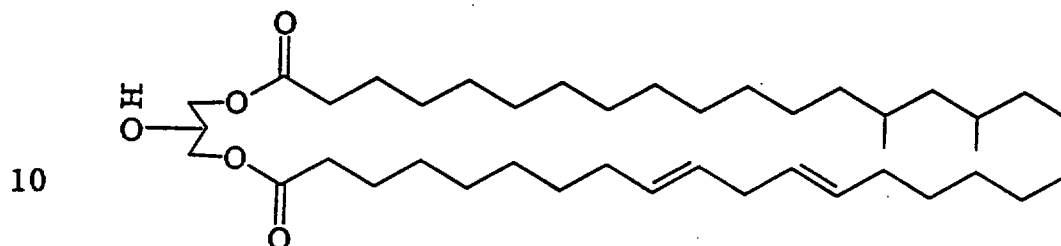
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What is claimed is:

- 5 1. A compound of the formula

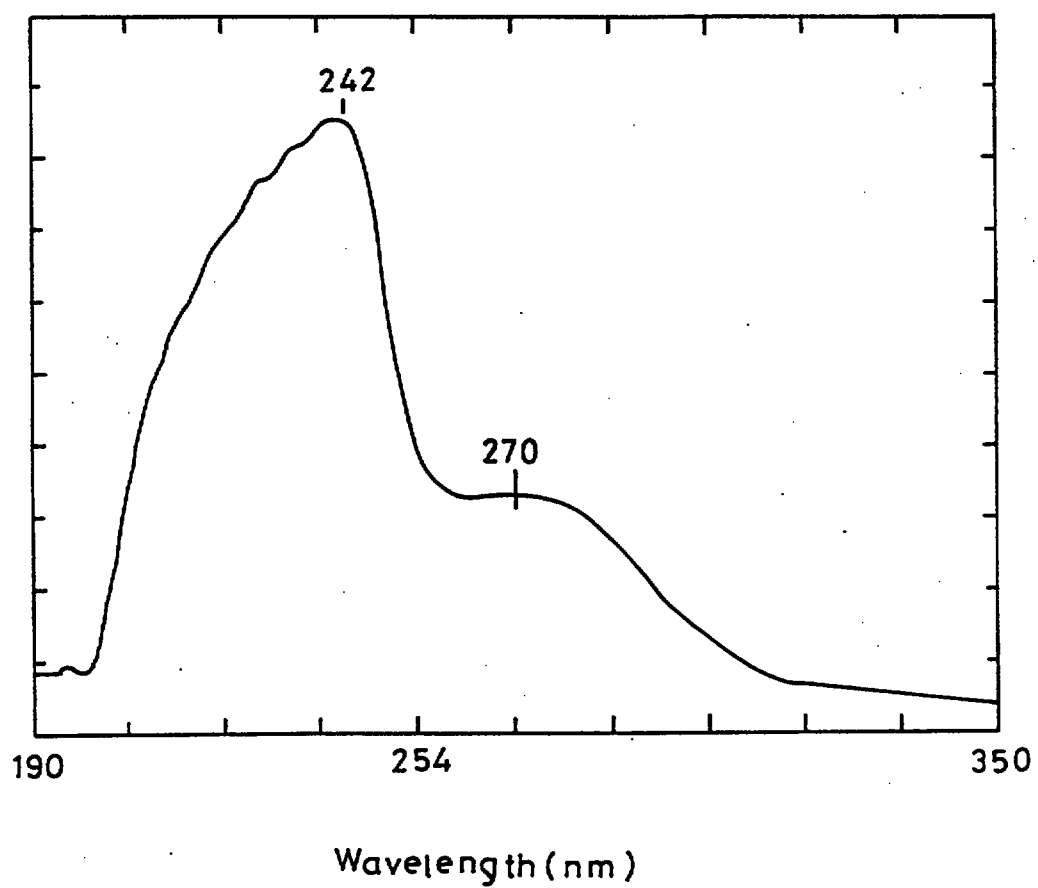


- 15 2. A microorganism *Streptomyces* sp. AL91 producing the *Legionella* specific antibiotic compound according to claim 1.
- 20 3. A process for producing the *Legionella* specific antibiotic compound according to claim 1 which process comprises cultivating the microorganism *Streptomyces* sp. AL91, extracting the cultural broth with isopropyl alcohol and ethyl acetate, and purifying the extracts by chromatography on column filled with octadecyl silica gel and in turn high pressure liquid chromatography to obtain
- 25 the said antibiotic compound.

30

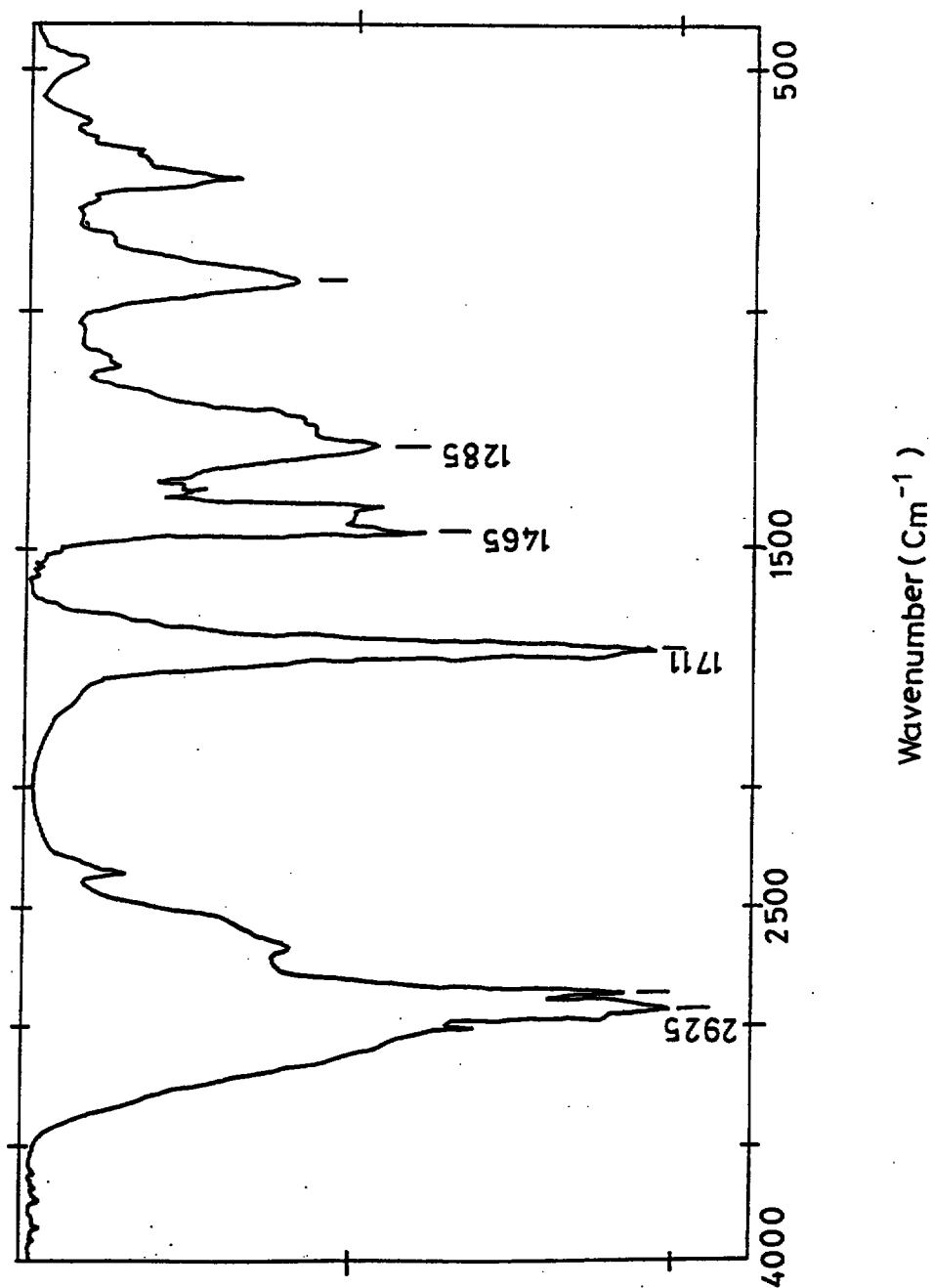
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**FIG.1**

2/5

FIG. 2



3/5

FIG. 3

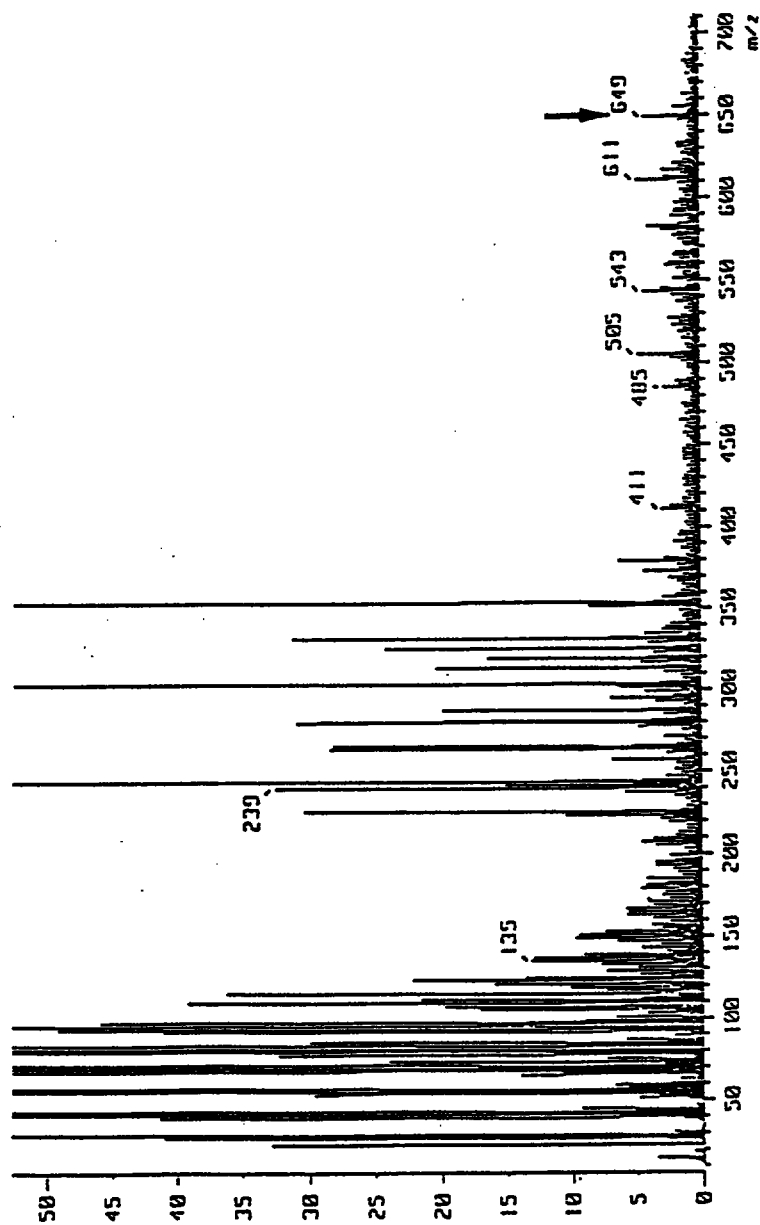


FIG. 4

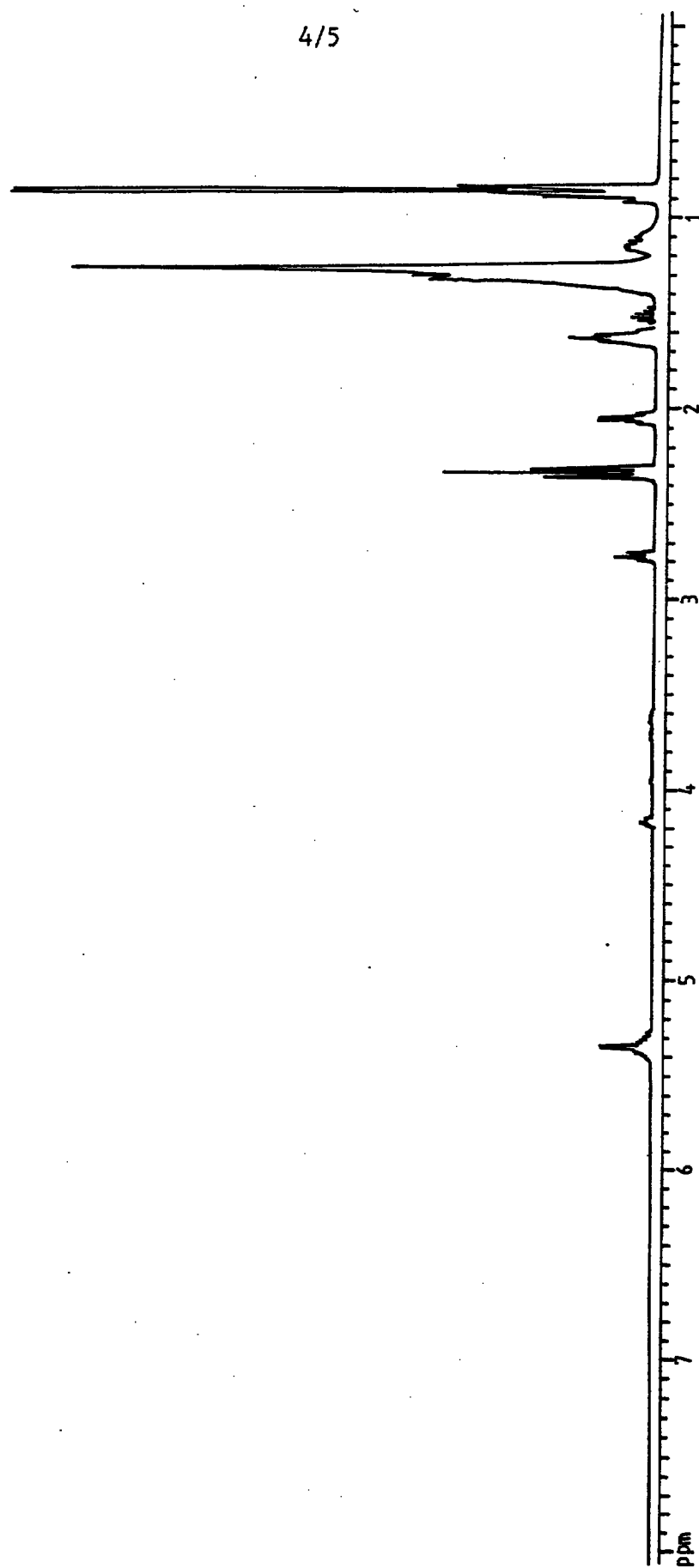
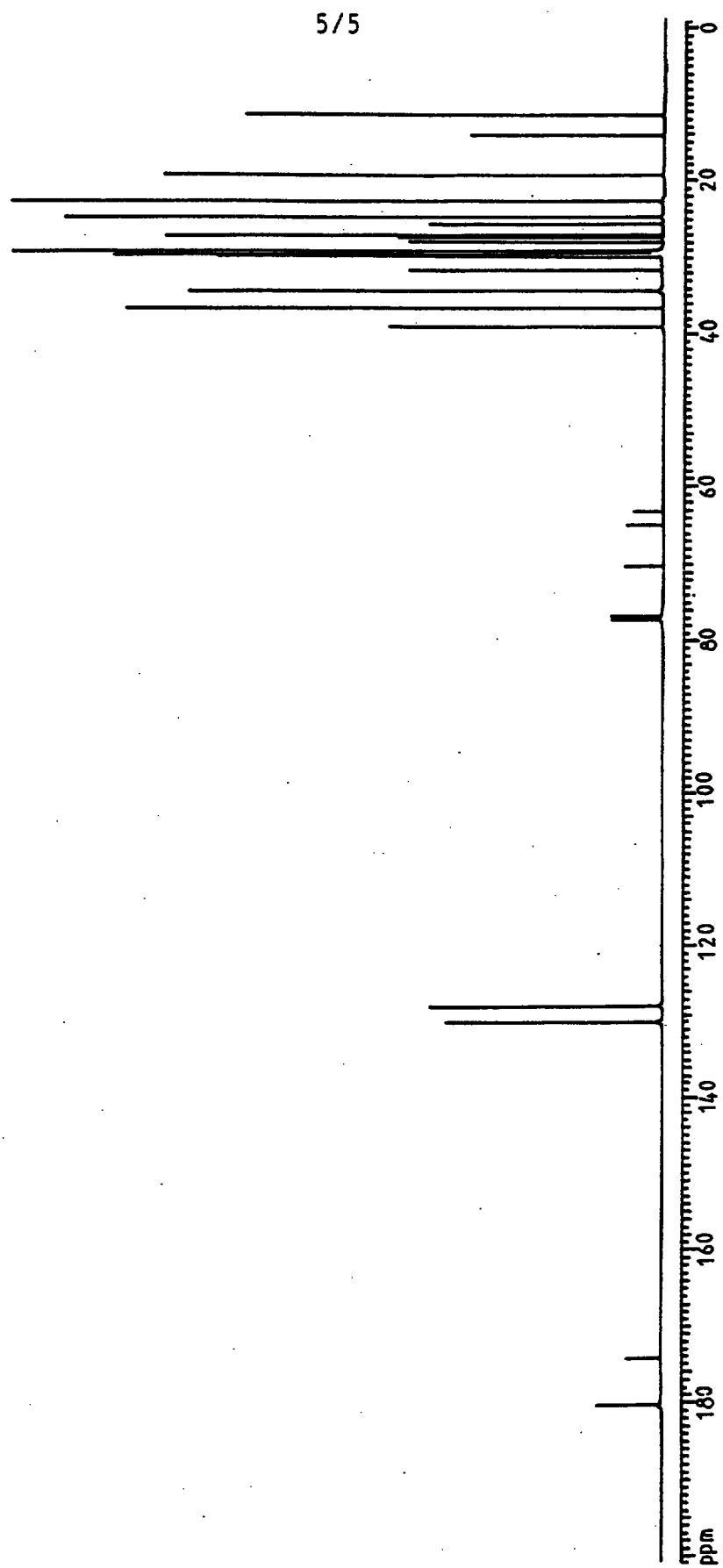


FIG. 5





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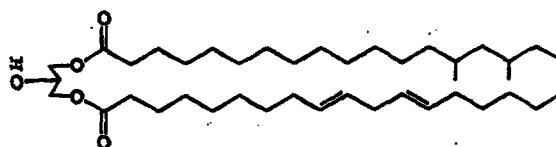
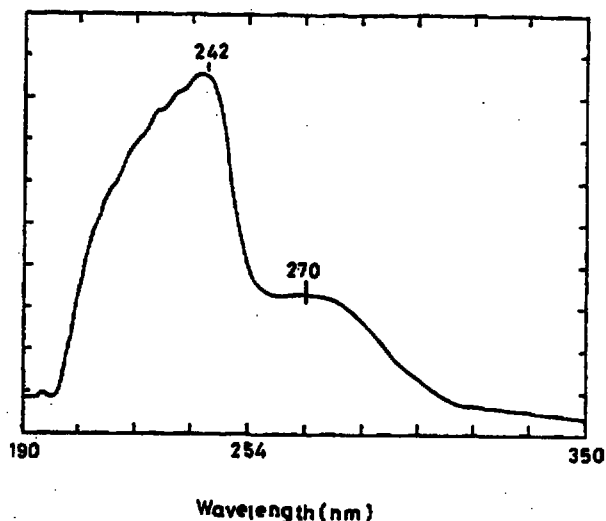
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PRODUCING THE SAME

## (57) Abstract

A novel *Legionella* specific antibiotic AL072, a novel  
*Streptomyces* sp. AL91 producing the same, and a process for  
producing the said antibiotic are disclosed. The structure of  
the said antibiotic compound is represented by formula (a).



(a)