

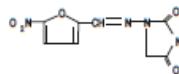
#### Nitrofurantoin Capsules, USP (monohydrate/microcrystals)

To reduce the development of drug-resistant bacteria and maintain the effectiveness of nitrofurantoin capsules, USP (monohydrate/microcrystals) and other antibacterial drugs, nitrofurantoin capsules, USP (monohydrate/microcrystals) should be used only to treat or prevent infections that are proven or strongly suspected to be caused by bacteria.

#### DESCRIPTION:

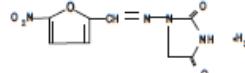
Nitrofurantoin is an antibacterial agent specific for urinary tract infections. Nitrofurantoin capsule, USP (monohydrate/microcrystals) is a hard gelatin capsule. Each capsule contains the equivalent of 100 mg of nitrofurantoin in the form of 25 mg of nitrofurantoin microcrystals, USP and 75 mg of nitrofurantoin monohydrate, USP.

The chemical name of nitrofurantoin monohydrate, USP is 1-[1-(6-nitro-2-furyl)methylene]amino]-2,4-imidazolidinedione. The chemical structure is as follows:



Molecular Weight: 238.16

The chemical name of nitrofurantoin monohydrate, USP is 1-[1-(6-nitro-2-furyl)methylene]amino]-2,4-imidazolidinedione monohydrate. The chemical structure is as follows:



Molecular Weight: 256.17

**Inactive Ingredients:** Each capsule contains enteric homopolymer type B (carboxymethylcellulose), corn starch, D & C Yellow No. 10, FD & C Blue No. 1, FD & C Red No. 40, gelatin, propyl alcohol, lactose monohydrate, magnesium stearate, mannitol, povidone K30, povidone K90, sodium lauryl sulphate, zinc, and titanium dioxide.

USP Dissolution Test is pending.

#### CLINICAL PHARMACOLOGY:

Each nitrofurantoin capsule (monohydrate/microcrystals) contains two forms of nitrofurantoin. Twenty-five percent is microcrystalline nitrofurantoin, which has a slower dissolution and absorption than nitrofurantoin monohydrate. The remaining 75% is nitrofurantoin monohydrate contained in a powder blend which, upon expansion in water, forms a granular suspension of nitrofurantoin monohydrate nitrofurantoin over time. Based on urinary pharmacokinetic data, the extent and rate of urinary excretion of nitrofurantoin from the 100 mg nitrofurantoin capsules (monohydrate/microcrystals) are similar to those of the 50 mg or 100 mg nitrofurantoin microcrystals capsule. Approximately 20% to 25% of a single dose of nitrofurantoin is recovered from the urine unchanged over 24 hours.

Plasma nitrofurantoin concentrations after a single oral dose of the 100 mg nitrofurantoin capsules (monohydrate/microcrystals) are low, with peak levels usually less than 1 mg/ml. Nitrofurantoin is highly soluble in urine, to which it freely imparts a brown color. When nitrofurantoin capsule (monohydrate/microcrystals) is administered with food, the bioavailability of nitrofurantoin is increased by approximately 40%.

#### MICROBIOLOGY

Nitrofurantoin is an antibacterial and antimicrobial agent with activity against certain Gram-positive and Gram-negative bacteria.

#### Mechanism of Action

The mechanism of the antimicrobial action of nitrofurantoin is unusual among antibiotics. Nitrofurantoin is reduced by bacterial flavoproteins to reactive furfural, which reacts with the thiol groups of proteins, particularly those in the macromolecules. As a result of such reactions, the vital biochemical processes of protein synthesis, aerobic energy metabolism, DNA synthesis, RNA synthesis, and cell wall synthesis are inhibited. Nitrofurantoin is bactericidal in vitro at therapeutic doses. The broad-spectrum nature of this mode of action may explain the lack of acquired bacterial resistance to nitrofurantoin, as the necessary multiple and mutagenic mutations of the target macromolecules would likely be lethal to the bacteria.

#### Interactions with Other Antibiotics

Antagonism has been demonstrated *in-vivo* between nitrofurantoin and quinolone antibiotics. The clinical significance of this finding is unknown.

#### Development of Resistance

Development of resistance to nitrofurantoin has not been a significant problem since its introduction in 1953. Cross-resistance with antibiotics and sulfonamides has not been observed, and transverse resistance is, at most, a very rare phenomenon.

Nitrofurantoin has been shown to be active against most strains of the following bacteria both *in-vitro* and in clinical infections (see INDICATIONS AND USAGE):

#### Aerobic and facultative Gram-positive microorganisms:

*Staphylococcus* spp.

#### Aerobic and facultative Gram-negative microorganisms:

*Candida* spp.

*Enterococcus* faecalis

*Enterococcus* faecium

*Escherichia coli*

*Klebsiella pneumoniae*

*Neisseria gonorrhoeae*

*Proteus mirabilis*

*Shigella* spp.

*Yersinia enterocolitica*

At least 90 percent of the following microorganisms exhibit an *in-vitro* minimum inhibitory concentration (MIC) less than or equal to the susceptible breakpoint for nitrofurantoin. However, the efficacy of nitrofurantoin in treating clinical infections due to these microorganisms has not been established in adequate and well-controlled trials.

#### Aerobic and facultative Gram-positive microorganisms:

*Enterococcus* spp.

*Staphylococcus aureus*

*Streptococcus agalactiae*

*Group D streptococci*

*Vibrio cholerae*

*Yersinia enterocolitica*

*Yersinia pseudotuberculosis*

*Yersinia enterocolitica*

dehydrogenase deficiency in the red blood cells of the affected patients. This deficiency is found in 10 percent of Blacks and a small percentage of ethnic groups of Mediterranean and non-Eastern origin. Hemolysis is an indication for discontinuing nitrofurantoin in people whose disease causes hemolytic anemia.

**Clostridioides difficile associated diarrhea (CDAD).** Clostridioides difficile associated diarrhea (CDAD) has been reported with use of nearly all antibiotic agents, including nitrofurantoin and may range in severity from mild diarrhea to fatal colitis. Treatment with antibiotic agents where the normal flora of the colon leading to overgrowth of *C. difficile*.

**C. difficile** produces toxins A and B which contribute to the development of CDAD. *C. difficile* producing strains of *C. difficile* cause increased morbidity and mortality as these infections can be refractory to antimicrobial therapy and may require colectomy. CDAD must be considered in all patients who present with diarrhea following antibiotic use. Careful medical history is necessary since CDAD has been reported to occur over two months after the administration of antibiotic agents.

If CDAD is suspected or confirmed, ongoing antibiotic use directed against *C. difficile* may need to be discontinued. Appropriate fluid and electrolyte management, protein supplementation, antibiotic treatment of *C. difficile*, and surgical evaluation should be initiated as indicated.

**PRECAUTIONS**  
**Information for Patients:** Patients should be counseled to take nitrofurantoin capsules (monohydrate/microcrystals) without delay if needed and to further enhance bioavailability and improving absorption. Patients should be instructed to complete the full course of therapy, however, they should be advised to contact their physician if any unusual symptoms occur during therapy.

Patients should be advised not to intend oral preparations containing magnesium trisilicate with taking nitrofurantoin capsules (monohydrate/microcrystals).

Patients should be counseled that antibiotic drugs, including nitrofurantoin which are used to treat bacterial infections. They do not treat viral infections (e.g., the common cold). When nitrofurantoin capsules (monohydrate/microcrystals) are prescribed for a bacterial infection, patients should be told that it is important to feel better early in the course of therapy. The medication may (1) decrease the effectiveness of the immediate treatment and (2) increase the likelihood that bacteria will develop resistance and will not be treatable by nitrofurantoin capsules (monohydrate/microcrystals) or other antibiotic drugs in the future.

**Gastroenteritis.** Diarrhea is a common problem caused by antibiotics which usually ends when the antibiotic is discontinued. Sometimes after starting treatment with antibiotics, patients can develop watery and bloody stools (with or without stomach cramps and fever) even as late as two or more months after having taken the last dose of the antibiotic. If this occurs, patients should contact their physician as soon as possible.

**General.** **Interactions:** Probenecid, sulfisoxazole capsules (monohydrate/microcrystals) in the absence of a primary or strongly suspected bacterial infection or a prophylactic indication is unlikely to provide benefit to the patient and increases the risk of the development of drug-resistant bacteria.

**Drug Interactions:**

Administration of nitrofurantoin capsules (monohydrate/microcrystals) in the presence of magnesium trisilicate, when administered concomitantly with nitrofurantoin, reduces both the rate and extent of absorption. The mechanism for this interaction probably is adsorption of nitrofurantoin onto the surface of magnesium trisilicate.

Urinary drugs, such as probenecid and sulfisoxazole, can inhibit renal tubular secretion of nitrofurantoin. The resulting increase in serum levels may increase toxicity, and the decreased urinary levels could lessen its efficacy as a urinary tract antibiotic.

**Carboxygenase Activity and Impairment of Fertility:**

Nitrofurantoin was not carcinogenic when fed to female Holstein rats for 44.5 weeks or to female Sprague-Dawley rats for 75 weeks. Two chronic rodent bioassays utilizing male and female Sprague-Dawley rats and two chronic bioassays in Swiss Webster mice and female Swiss Webster mice revealed no evidence of carcinogenicity.

Nitrofurantoin presented evidence of carcinogenic activity in female B6C3F1 mice as shown by increased incidences of tubular adenomas, benign mixed tumors, and granuloma cell tumors of the liver. In male B6A4N rats, there were increased incidences of uncommon kidney tubular cell neoplasms, osteosarcoma of the bone, and neoplasms of the subcutaneous tissue. In one study involving subacute oral administration, 75 mg/kg nitrofurantoin in pregnant female mice, lung papillary adenomas of unknown significance were observed in the F1 generation.

Nitrofurantoin has been shown to induce point mutations in certain strains of *Salmonella typhimurium* and *Escherichia coli* strains. Nitrofurantoin induced increased numbers of sister chromatid exchange and chromosomal aberrations in Chinese hamster ovary cells but not in human cell cultures. Results of the sex-linked recessive lethal assay in *Drosophila* were negative after administration of nitrofurantoin by feeding or by injection. Nitrofurantoin did not induce heritable mutation in the *Drosophila* strain examined.

The significance of the carcinogenicity and mutagenicity findings relative to the therapeutic use of nitrofurantoin in humans is unknown.

The administration of high doses of nitrofurantoin to rats causes temporary testicular atrophy; this is reversible on discontinuing the drug. Doses of 10 mg/kg or greater in healthy human males may in certain unpredictable instances produce a slight moderate spermatoxic effect with a decrease in sperm count.

295.00 mm

350.00 mm

**Pregnancy:**

**Teratogenic effects:**

Pregnancy Category B. Several reproduction studies have been performed in rabbits and rats at doses up to six times the human dose and have revealed no evidence of impaired fertility or harm to the fetus due to nitrofurantoin. In a single published study, administration at 60 times the human dose (based on mg/mg administered) to the dog, gave no evidence of malformation, but a few minor common malformations were observed. However, at 25 times the human dose, fetal malformations were not observed; the relevance of these findings to humans is uncertain. There are, however, no adequate and well-controlled studies in pregnant women. Because animal reproduction studies are not always predictive of human response, this drug should be used during pregnancy only if clearly needed.

**Non-teratogenic effects:**

Nitrofurantoin has been shown in one published transplacental carcinogenicity study to induce renal papillary tumors in the F1 generation mice at doses 19 times the maximum recommended human dose. The mechanism of tumor induction is unknown. The relevance of this finding to humans is uncertain. Human carcinogenesis is presently unknown. Because of the uncertainty regarding the human implications of these animal data, this drug should be used during pregnancy only if clearly needed.

**Labor and Delivery:**

**See CONTRAINDICATIONS.**

**Nursing Mothers:**

Nitrofurantoin has been detected in human breast milk in trace amounts. Because of the potential for serious adverse reactions from nitrofurantoin in nursing infants under one month of age, a decision should be made whether to discontinue nursing or to discontinue the drug, taking into account the importance of the drug to the mother. (See CONTRAINDICATIONS.)

**Pediatric Use:**

Nitrofurantoin capsules (monohydrate/microcrystals) are contraindicated in infants below the age of one month. (See CONTRAINDICATIONS.) Safety and effectiveness in pediatric patients below the age of twelve years have not been established.

**Geriatric Use:**

Clinical studies of nitrofurantoin capsules (monohydrate/microcrystals) did not include sufficient numbers of subjects aged 60 and over to determine whether they respond differently from younger subjects. Other clinical experience and postmarketing reports do not indicate differences in responses between the elderly and younger patients. Spontaneous reports suggest a higher proportion of pulmonary reactions, including fatalities, in elderly patients; these differences appear to be related both to higher proportion of elderly patients receiving long-term nitrofurantoin therapy. As in younger patients, chronic pulmonary reactions generally are observed in patients needing therapy for longer than 1 month. (See WARNINGS.) Spontaneous reports also suggest an increased proportion of severe hepatic reactions, including fatalities, in elderly patients (see WARNINGS).

In general, the greater frequency of decreased hepatic, renal, or cardiac function, and of adverse events associated with the use of nitrofurantoin capsules, considered when prescribing nitrofurantoin capsules (monohydrate/microcrystals). This drug is known to be substantially excreted by the kidney, and the risk of toxic reactions to this drug may be greater in patients with impaired renal function. Anuria, oliguria, or significant impairment of renal function (creatinine clearance under 60 mL per minute or clinically significant elevated serum creatinine) are contraindications (see CONTRAINDICATIONS). Because elderly patients are more likely to have decreased renal function, it may be useful to monitor renal function.

**ADVERSE REACTIONS:**

In controlled clinical trials, the most frequent clinical adverse events that were reported as possibly or probably drug-related were nausea (2%), headache (6%), and flatulence (1.8%). Additional clinical adverse events reported as possibly or probably drug-related occurred in less than 1% of patients studied and are listed below within a body system in order of decreasing frequency.

**Gastrointestinal:** Diarrhea, dyspepsia, abdominal pain, constipation, emesis

**Neurologic:** Dizziness, drowsiness, amnesia

**Respiratory:** Acute pulmonary hypersensitivity reaction (see WARNINGS)

**Allergic:** Pruritis, urticaria

**Dermatologic:** Alopecia

**Miscellaneous:** Fever, chills, malaise

The following additional clinical adverse events have been reported with the use of nitrofurantoin:

**Gastrointestinal:** Stomatitis, pancreatitis. There have been sporadic reports of pseudomembranous colitis with the use of nitrofurantoin. The onset of pseudomembranous colitis symptoms may occur during or after antimicrobial therapy. (See WARNINGS.)

**Neurologic:** Peripheral neuropathy, which may become severe or irreversible, has occurred. Patients have been reported. Conditions such as renal impairment (creatinine clearance under 60 mL per minute or clinically significant elevated serum creatinine), anemia, diabetes mellitus, electrolyte imbalance, vitamin B deficiency, and debilitating diseases may increase the possibility of peripheral neuropathy. (See WARNINGS.)

**Auditory:** Tinnitus, vertigo, and tinnitus also have been reported with the use of nitrofurantoin.

Benign intracranial hypertension (pseudotumor cerebri), confusion, depression, optic neuritis, and psychotic reactions have been reported rarely. Bulging fontanelles, as a sign of benign intracranial hypertension in infants, have been reported rarely.

**Respiratory:**

**CHRONIC, SUBACUTE, OR ACUTE PULMONARY HYPERSensitivity REACTION:** MAY OCCUR IN PATIENTS RECEIVING THERAPY FOR CHRONIC PULMONARY CONDITIONS. THESE REACTIONS GENERALLY OCCUR IN PATIENTS WHO HAVE RECEIVED CONTINUOUS TREATMENT FOR SIX MONTHS OR LONGER. MALAISE, DYSPNEA ON EXERTION, COUGH, AND ALTERED PULMONARY FUNCTION ARE COMMON MANIFESTATIONS WHICH CAN OCCUR INSIDIOUSLY. RADIOLOGIC AND HISTOLOGIC FINDINGS OF

**DIFFUSE INTERSTITIAL PNEUMONITIS OR FIBROSIS, OR BOTH, ARE ALSO COMMON MANIFESTATIONS OF THE CHRONIC PULMONARY REACTION.**

**FEVER IS RARELY PROMINENT.**

**THE SEVERITY OF CHRONIC PULMONARY REACTIONS AND THEIR DEGREE OF RESOLUTION APPEAR TO BE RELATED TO THE DURATION OF THERAPY AFTER THE FIRST CLINICAL SIGNS APPEAR. PULMONARY FUNCTION MAY BE IMPAIRED PERMANENTLY, EVEN AFTER CESSION OF THERAPY. THE RISK IS GREATER WHEN CHRONIC PULMONARY REACTIONS ARE NOT RECOGNIZED EARLY.**

In subacute pulmonary reactions, fever and eosinophilia occurs often than in the acute form. Usual duration of therapy/recovery may require several months. If the reaction is not recognized as being drug-related and nitrofurantoin therapy is not stopped, the symptoms may progress.

**Acute pulmonary reactions are commonly manifested by fever, chills, cough, chest pain, dyspnea, pulmonary infiltration with consolidation or pleural effusion (xanthochromic, and eosinophilic). Acute reactions usually occur within the first week of treatment and are reversible with cessation of therapy. Resolution often is dramatic. (See WARNINGS.)**

Changes in EKG (e.g., non-specific ST/T wave changes, bundle branch block) have been reported in association with pulmonary reactions.

Cyanosis has been reported rarely.

**Hepatic:** Hepatic reactions, including hepatitis, cholestatic jaundice, chronic active hepatitis, and hepatocarcinoma, occur rarely. (See WARNINGS.)

**Angioedema:** Angioedema is a symptom associated with pulmonary reactions to nitrofurantoin. Other reported manifestations of nitrofurantoin-induced angioedema, or eosinophilic syndrome, anaphylaxis, arthralgia, myalgia, and fever, chills and vasculitis (sometimes associated with pulmonary reactions) have been reported. Hypersensitivity reactions represent the most frequent spontaneously-reported adverse events in worldwide postmarketing experience with nitrofurantoin formulations.

**Dermatologic:** Exfoliative dermatitis and erythema multiforme (including Stevens-Johnson syndrome) have been reported rarely.

**Hematologic:** Cyanosis secondary to methemoglobinemia has been reported rarely.

**Misconceives:** As with other antimicrobial agents, superinfections caused by resistant organisms, e.g., *Pseudomonas* species or *Candida* species, can occur.

In clinical trials of nitrofurantoin, the most frequent laboratory adverse events (1% to 5%), without regard to drug relationship, were as follows: eosinophilia, increased AST (SGOT), increased ALT (SGPT), decreased hemoglobin, increased serum phosphorus. The following laboratory adverse events also have been reported with the use of nitrofurantoin: glucose-6-phosphate dehydrogenase deficiency (G6PD) (and with nitrofurantoin, agranulocytosis, leukopenia, thrombocytopenia, hemolytic anemia, thrombocytopenia, megakaryotic anemia). In most cases, these hematological abnormalities resolved following cessation of therapy. Aplastic anemia has been reported rarely.

To request medical information or to report SUSPECTED ADVERSE REACTIONS, contact Invirite Healthcare Limited at 1-855-42-2994 or FDA at 1-800-FDA-1084 or [www.fda.gov/marwatch](http://www.fda.gov/marwatch).

**OVERDOSE:**

Large amounts of acute overdose of nitrofurantoin have not resulted in any specific symptoms other than vomiting. Induction of emesis is recommended. There is no specific antidote, but a high fluid intake should be maintained to promote urinary excretion of the drug. Nitrofurantoin is dialyzable.

**DOSAGE AND ADMINISTRATION:**

Nitrofurantoin capsules (monohydrate/microcrystals) should be taken with food.

**Adults and Pediatric Patients Over 12 Years:** One 100 mg capsule every 12 hours for 5 days.

**HOW SUPPLIED:**

Nitrofurantoin capsules, USP (monohydrate/microcrystals), 100 mg, are supplied as a light yellow low powder blend and yellow colored tablet filled in the hard gelatin capsule shell size "1" with black cap imprinted "100" and yellow colored body imprinted "102".

NDC 09746-762-01 bottle of 100  
NDC 09746-762-36 bottle of 1000

Store at controlled room temperature (59° to 86° F or 15° to 30°C).

**Rx Only**

**Clinical Studies:**

Comparative clinical trials comparing nitrofurantoin 100 mg p.o. q12h and nitrofurantoin microcrystals 50 mg p.o. q8h in the treatment of acute uncomplicated urinary tract infections demonstrated approximately 75% microbiologic eradication of uropathogens in each treatment group.

**Manufactured by:**  
 Invirite Healthcare Limited  
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